

# INTERNATIONAL CONFERENCE ON OCEAN POLLUTION

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HEARINGS  
BEFORE THE  
SUBCOMMITTEE ON OCEANS AND ATMOSPHERE  
OF THE  
COMMITTEE ON COMMERCE  
UNITED STATES SENATE  
NINETY-SECOND CONGRESS  
SECOND SESSION  
ON  
INTERNATIONAL CONFERENCE ON OCEAN  
POLLUTION

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OCTOBER 18 AND NOVEMBER 8, 1971

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# CONTENTS

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Opening statement by Senator Hollings.....	Page 1, 39
--	---------------

## CHRONOLOGICAL LIST OF WITNESSES

OCTOBER 18, 1971

Carpenter, Scott, former NASA Astronaut.....	28
Cousteau, Captain, Jacques.....	3
Herter, Christian A., Jr., special assistant to the Secretary of State for Environmental Affairs.....	34
Morton, Mark, vice president and group executive, General Electric Co....	18
Biographical sketch.....	17

NOVEMBER 8, 1971

Commoner, Dr. Barry.....	56
Prepared statement.....	119
Downs, Hugh.....	119
Heyerdahl, Dr. Thor.....	44
Biographical sketch.....	42

(III)

# INTERNATIONAL CONFERENCE ON OCEAN POLLUTION

MONDAY, OCTOBER 18, 1971

UNITED STATES SENATE,  
COMMITTEE ON COMMERCE,  
SUBCOMMITTEE ON OCEANS AND ATMOSPHERE,  
*Washington, D.C.*

The subcommittee met, at 10:00 a.m., in Room 318, New Senate Office Building, Hon. Ernest F. Hollings (chairman of the subcommittee) presiding.

Present: Senators Hollings, Baker, Cook and Stevens.

Also present: Congressmen Alton Lennon, John D. Dingell, and George E. Shipley.

## OPENING STATEMENT BY SENATOR HOLLINGS

Senator HOLLINGS. Good morning. I am very pleased to welcome you to the first session of the International Conference on Ocean Pollution, convened by the Committee on Commerce.

We are delighted, of course, to have our distinguished members of the committee, Senator Stevens and Senator Cook, and later in the day, Senator Spong will be along. And we are particularly pleased to have Congressman Shipley with us, of the Appropriations Committee, and the former Chairman of the American Oceanic Organization.

I hope also Congressman Lennon, the Chairman of the Oceanography Subcommittee on the House side, and Congressman Dingell of the Fisheries and Wildlife Conservation Subcommittee, will be along.

Before we introduce our first speaker, I want to extend a special welcome to the members of the Diplomatic Corps who have shown the concern to be with us today, especially Ambassador Arguelles of Spain, Ambassador Botha of South Africa, Ambassador Galvez of Honduras, Ambassador McComie of Barbados, and the acting Ambassador of Portugal, Charge d'Affaires Matias.

We welcome these gentlemen and other representatives of other governments, because we are confident that whatever we do here in the United States will have no effect whatever on the pollution of the oceans unless similar action is taken by the world community.

As we start this first of a series of sessions on ocean pollution, it is appropriate to ask why are we really concerned about ocean pollution? There are over 145 million square miles of ocean surface.

Staff member assigned to these hearings: John Hussey.

Seemingly this vast body of water could act as an excellent sink to absorb the wastes that mankind generates.

We now know clearly that the oceans cannot absorb all of man's waste. The heavy metals, the oils, the chemical and biological warfare agents, industrial and municipal wastes, not only affect man's health but they also have a profound impact on the fish, marine mammals, birds, and plant life that inhabit the sea.

In the United States alone it is estimated by the Bureau of Solid Waste Management—now the Environmental Protection Agency—that we dispose of 365 million tons of wastes annually. Forty-eight million tons were estimated by the Council on Environmental Quality to have been dumped in the sea in 1968. Of course, that figure is much larger now. Over 1 million metric tons of oil reach the sea just in the course of transportation by tanker annually. And this does not take into account the oil from the crankcase of your and my automobile when it is changed at the service station, from refineries, submarine oil wells, and airborne hydrocarbons from automobiles, factories and home furnaces and the like.

Gentlemen, we are convinced that a crisis is at hand, that it is a crisis that not only concerns the quality of pollutants that we are putting into the world's oceans and the devastating effects, but it is also a crisis of inattention, incomprehension, and inactivity. Appropriate solutions to ocean pollution can be found at the local, national, and international levels. But where can we find the people's attention? If the world's great oceans die, then man will die.

We are fortunate to have with us today four men eminently qualified to discuss the problem of ocean pollution from a broad viewpoint. Captain Jacques Cousteau has traveled all the way from France to be with us. He is internationally known. His contributions to oceanography and marine exploration are probably better known than any contributions to oceanography during our time.

We are also very fortunate to have Mr. Mark Morton, the executive vice president of the General Electric Co. His company is daily involved in exploring new uses of the seas and improving man's ability to work in them. There is no better witness on technology and technological challenge that the United States now faces.

My oldtime friend, Scott Carpenter, who has been in the space and under the sea from the Mercury man-in-space project to the man-in-the-sea project, brings a wealth of knowledge and personal experience.

Later in the morning Mr. Christian Herter, Jr., Assistant to the Secretary of State for Environmental Affairs, will be here. He is directly involved in the United States preparations for the 1972 United Nations Conference on the Human Environment next June in Stockholm.

We will have as our first witness our explorer and film-maker friend, Captain Cousteau.

While you take your seat, Captain, I want to welcome to the Committee Congressman John Dingell who has been Chairman of the Subcommittee on Fisheries and Wildlife Conservation of the House Merchant Marine and Fisheries Committee.

These gentlemen of the House, I might say, Captain Cousteau, and for the audience, have already passed an ocean pollution bill. I think

it is an excellent bill. We would like to pass it *carte blanche* without changing even a word and have it written into law. We have a little hangup over here on Committee jurisdiction, but we hope that is resolved.

I hope the testimony that you will give to this committee and to the Congress generally will point up the importance of this particular problem. We will be glad to hear from you at this time.

### STATEMENT OF CAPTAIN JACQUES COUSTEAU

Captain COUSTEAU. Mr. Chairman, I am greatly honored to have been invited to appear here today, and I am impressed by your responsibility to talk about the element to which I have devoted my life, the sea.

The sea, as everybody today knows, is threatened. We generally restrain and reduce the scope of the question, the problem that the ocean faces, by speaking only of pollution. In fact, what we are facing is the destruction of the ocean by pollution and by other causes.

It is difficult to analyze the sources, but we have to do so if we want to understand and to react.

My role in this gigantic enterprise is only that of a witness, a modest witness, who has only one valuable thing to testify about and it is, I think, a unique quality of experience—underwater searching for more than 30 years.

I am fortunate enough to have shared this 30 years with the same companions most of the time, companions that have stayed with me 15, 20, 25 years, and that have been diving in most places of the world since then, joining their observations to mine. So it is really a heap of observations that I try to analyze and to sum up in a few words, in a few sentences, today.

The interesting thing is that we have been visiting the same places often 20 years apart, in the Northern as well as in the Southern Hemispheres, so we could make comparisons and judge the facts of damage that was done.

The only trouble is that our observations are subjective. It is impossible to quantify the general damage done to the ocean by specific measurements, or if we wanted to do so we would need thousands of such measurements. But the behavior is immediately seen when you look at one place several years apart, what the trend is, what the gradient is. We have been doing so not only along the coast, but in the most remote islands, not only near the surface but in exploring submarines down to 1,000 feet as early as 1959, and now currently, to 2 and 3 thousand feet.

The figure that I have already given last year I can only confirm. We believe that the damage done to the ocean since 20 years is somewhere between 30 percent and 50 percent, which is a frightening figure. And this damage carries on at very high speed.

I have already been mentioning in articles of communications about the damage done to the Indian Ocean, to the Red Sea, to the Mediterranean, to the Atlantic. Our latest observations in the Pacific, in Micronesia and New Caledonia and in the Fiji Islands are even more frightening. Everywhere around the world the coral reefs are disappearing at a very great rate, to such an extent we are not sure we will see anything like what we know now. In New Caledonia, for example, the

destruction is due partly to pollution, partly due to fishing, and partly also by manual destruction. There are teams of Tahitian divers with crowbars destroying an average of 10 kilometers of reef a week. They have discovered shells inside the corals, but they have to destroy the coral to find live shells today. They are sent to museums and shops that sell them to the public all around the world. So the demand of the public is responsible indirectly for this constant destruction of the oceans all around the world.

This is just an example among thousands.

The field of damage done by pollution is immense, as you can see by just throwing an eye to the American publication "Pollution Abstract." Thousands of papers are already published about pollution.

But I would like to react very strongly against the belief that before acting against pollution we must know by research. Scientific research is very much necessary and must be increased many-fold, as I will tell later on. But I was very much impressed by a sentence wherein in a book by the French writer Fenechelon, in a very short sentence speaking of the scientists measuring while the destruction goes on, she says, "They measure, we weep."

The action that is now necessary must be taken I think without knowing, even if we have to make some mistakes, because there is no time to lose. Otherwise, it will be too late.

Some scientists in this country are more pessimistic than I am. Many of them when they are privately asked think that it is already too late, that nothing can be done. It is not my opinion, but I am absolutely certain that we have no time to lose, that we have a race against time, and that we must all join forces to win that battle.

I am tempted at times to feel satisfied, to see the increasing interest in the public of these problems, because I remember in 1959 when we started our action we caused a near scandal, and we unfortunately were right. But this satisfaction is obliterated by the fact of news from my three research units. I put on the left side the bad news and on the right side the good news. There is good news, but there is much more bad news than good news today.

One may wonder why so little care has been given to the ocean in the past. The reason is very simple. People have thought that the legendary immensity of the ocean was such that man could do nothing against such a gigantic force. Well, now we know that the size of the ocean, although it covers a great amount of surface, the real volume of the ocean is very small compared to the volume of the earth, and that this water reserve on our spaceship is unfortunately very small.

By the same token, we know now that the cycle of life is intricately tied up with the cycle of water, so that anything done against the water is a crime against life. The water system has to remain alive if we are to remain alive on this earth. Demonstration has been done long ago, and there is no reason to expand on this. This is so true that we have to change completely our minds about what kind of pollutions there are.

In publications, in conferences, in international units the matters are generally divided into air pollution, land pollution, and water pollution. In fact, there is only one pollution because every single thing, every chemical whether in the air or on land will end up in the ocean.

I have recent figures here about this. I won't bother you too much, but one of them is frightening. We know now already that 25 percent of all the DDT compounds so far produced are already in the sea. They will all end up in the sea finally. But already 25 percent has reached the sea—cadmium, mercury, all these problems—I don't think I would like to bother you with these figures. But the general phenomenon is that as soon as we discover a new source of pollution, the producers of the pollutant subsidize another research, a counter research, and finally they come out with statements that this pollution is good for you.

So it is very difficult to know the truth from these two sources. It is obvious that damage is done, but it is difficult to pin down the villain or villains.

Some of the pollutions are probably more damaging than we think; some less. The future will show. But as the Minister of the Environment in Canada told me, the only solution is to require by law the polluters to keep all the toxic products within their fences. This is the only attitude to clean the world.

Another reason for damaging of the ocean or for the deterioration of the ocean is overfishing. I made some forecasts 2 years ago saying that the amount of life in the ocean is decreasing rapidly. The only reason why the tonnage of fish still was going up was the improvement of equipment, and I forecasted that this tonnage will still go up for 10 years before decreasing.

I was too optimistic. This year for the first time the world tonnage of fish has gone down slightly, beginning a curve and announcing a sharp fall which is going to happen. So the curve I anticipated is by far not accurate.

The other reason for the destruction of the oceans is unconstant changes in the environment. Blends are artificially introduced by man without knowing what they are doing, or other animals are destroyed in order to save another species without also knowing what we are doing.

I will give you one striking example. The famous starfish has been responsible for the destruction of the coral reefs. Dozens of divers make injections of formulae inside the poor animals, and by doing so they are absolutely not helping the environment. These starfish are only doing their job as they have done since the beginning of the world, and this job is to clean these corals that are in a poor condition.

Now, all over the world the corals are dying and they are taking advantage of that situation.

Another example in California is frightening. As you know, there is in California an ecosystem, very simple, that is often cited as an example—the sea otter, the kelp, the urchin and the abalone. Two hundred years ago the sea otter was abundant all along the coast of California. Now, it has been eradicated—almost eradicated in the south. The absence of the sea otter in the south makes a threat to the kelp beds by encouraging the urchins to eat the kelp roots, and sea otters are not there to eat the sea urchins and to keep the balance.

Some scientist in despair found out two solutions: One was to spread chemicals on the bottom of the sea, and the other solution was to send divers with hammers down to crush the urchins by the thou-

sands, to kill them on the spot. So any kind of such action—it is a tremendous waste.

But apart from that, what worries me is to see when we are in trouble, the only remedy we can invent is to add another destruction to the destruction we witnessed. This is really, when we think about it, a terrible responsibility.

Another thing I wanted to quickly mention, as you know in 1960 several studies demonstrated in 60 years, from 1900 to 1960, more than 800 species had been exterminated definitely by man. I don't have up-to-date figures today, but having put the curve on a piece of paper it shows that we must pass the thousand species mark in several years. This is rather frightening, but there is a counter point to this: each time man has protected a species—and I have examples, striking examples—a turnback has occurred. Nature is ready to respond to any kind of action we take with spectacular speed and efficiency. I name quickly the gray whale, the sea otter. Each time man has really protected an animal, officially protected an animal, even if it was near extinction, it came back.

So there is hope if it is not too late.

I am thinking today particularly of the California condor. You know, it is a hot subject at the moment. There are only 50 of these beautiful birds left in a small area. There are several development companies that want absolutely to get that piece of land, the last refuge of the condor. If we protect them I'm quite sure that they will respond to this protection.

I cannot help feeling that the main reason for the quick destruction of our planet by man is something that has a psychological remedy. Man has probably been on this planet since about 1 million years. Until the start of the industrial revolution—let's say five generations ago—man has disposed of only a maximum power of one horse, and his number and his absence of weapons, of natural weapons, made him an indentured creature of nature.

So during all these years, this million years, man had to fight nature. He had no fangs, no protection, soft skin; he had to fight nature just to survive.

Certainly in five generations because of the industrial development, we must completely change our thinking, reverse it 180 degrees, and understand that the only chance of survival is not to fight nature but it has become to protect nature.

This change-about in our psychology is almost impossible to do without a tremendous effort. So I believe that the remedy is psychological. We must clearly become conscious of this change, and then things can happen.

If we leave the philosophical level and if we come down to the analytical level, social level, the main responsible factors for the destruction of the planet are obviously over-population; and not enough has been done on that subject. And also the fact the law of competition has not been tamed yet. Competition is sound if it is tamed, if it is organized. Competition is wild and destructive if it is untamed.

The fact that the international competition has such implications obliged us—international competition—to stay in the wild area, untamed. As long as we do not tame this competition by international regulations and understanding, there will be no hope of controlling our development, switching our technology from quantity producing to

quality producing, and to apply surgery to an unregulated development that can only be compared to cancer.

Unfortunately, the authorities are so overwhelmed by day-to-day problems, problems that involve the coming generations are often put under the pile.

What about the first beginning of a plan? I would like to bring just a remark to this question: It has been said over and over again that the cost of cleaning the planet would be for the main nations about 5 or 6 percent of the gross national product every year. That is, for the United States, approximately \$50 billion a year, which seems a fantastic lot of money, almost two-thirds of the military budget. So it is the scale of the economy, and the problem is whether to pay 5 or 6 percent more for everything in order to survive. People are pessimistic, saying nobody will accept such raises in prices. My answer to this is they will. And they have done so at times. The emergence of the credit card in the economy has raised the general cost of living in 10 years about that amount with nobody protesting. The implications of the credit card, they are not by far as great as the scope of insuring the survival of mankind. The cost of cleaning the planet will be slightly more than the cost of a credit card, but not much more.

The remedies that should be applied are the intensification of research, of course. We can estimate the budget necessary in several ways. One arbitrary way is to say we need at least 20 times more money for pollution research than we have now. Another way of doing it is reform. The total volume of the marine activities in the world amounts to \$450 billion, not encompassing the military expenditures which takes about 20 to 25 percent. This includes every activity, including fishing, transportation, but not the military budgets.

If 1 percent of that money was applied—1 percent is a common figure for research in big companies—if 1 percent of that figure was applied to marine research, it would mean that the world would spend in a year \$4.5 to \$5 billion for marine research. We are far from doing so. The share for the United States would be almost \$2 billion.

I think today that hardly \$600 million are spent. So this is an indication of what would be reasonable to spend for the United States, and this is the only way for this country to find supremacy in this field that it had just up to World War II.

The drop in American research, marine research, occurred sharply in 1968, and today only applied research can be conveniently funded. Fundamental research is sacrificed, having the result that fundamental scientists camouflage their goals in order to find funds, which I think is a very poor way of presenting research. The research would take years before it would bring about results, and as I said before, we have to act before we get this research.

The second remedy is to educate the public. Obviously television is the best tool but there is another one which is even better—it is the children. Today the American family is very much influenced by the children. The kind of education the children get is much higher than the one the parents got, and a teenager is today the educator of the average American family. He comes back from school with his head filled with new facts, and he tells them to his mother—he rarely speaks to his father about these things, because his father should know everything—and the mother listens. And the mother speaks about it

in the evening to the father, and the facts about pollution, about environment, are penetrating the families through two channels—television and school.

I made a census because I am depending a lot on the television public and I want to know what they think—I made a census of the average public in the United States, and I found out that 90 percent of the women are favorable to sacrificing some of their comfort for the protection of the environment; all the children practically are ready to do so, and only 20 percent of the men. But the women vote.

I think personally that with these figures in hand, the battle can be won through the children and the women.

A third point is to persuade the producers. I thought it would be difficult. I don't think so now. As soon as the producers understand that they are not going to be the ones to pay for it they are delighted.

So, the only thing is to explain to them that they have to make an effort, but that they can include the cost of cleaning the environment in the cost of their products as they include the salaries, the raw material, the taxes, investment, etc.

The fourth point—of course, I will go quickly on these points—is to establish drastic national and international legislation. The role of the governments is not to pay for the cleaning of the planet. The role of the governments is to pay for research and to establish education.

We have now a hope with the Stockholm Conference. It is a big hope because the Stockholm Conference is going to bring about the greatest amount of thinking on this subject that has ever occurred. It will be very useful on this level. But we have to be very careful about the proposals or the resolutions that come out from the Stockholm Conference, because the problems unfortunately cannot be generalized.

The polluting countries are not in the same situation as the non-polluting countries. To try to find a development at the level of the United Nations would be burying the entire idea.

The action before the United Nations has to be diplomatically acceptable for such countries as Xanzania, so that efficiency cannot emerge from the United Nations, it is impossible.

Taking, for example, DDT. The DDT problem was brought up at the United Nations. Nations like Sweden, the United States, will take steps on DDT. But the United Nations cannot, because some of the nations are dependent on it for their crops and for their very survival today still—and as long as we have not found another way, they will continue to use it.

So, we have to divorce the good will of the United Nations from the immediate action taken by the advanced nations.

Another reasons for my proposal, for the proposal I will make in a moment, is that together with Sweden, the United States is by far the Nation in which the public is most aware of these problems—thanks to school and television.

So, I think that the United States should soon after the Stockholm Conference invite the 14 or 18 most industrialized nations which account for 82 or 83 percent of the pollution to the world, to join forces here in Washington and discuss emergency measures that everybody will accept so that competition becomes tame again.

To sum up, I would like also to bring your attention to one point. It is good to make regulations and laws, but who is going to control them? It is obvious that the governments or the United Nations cannot do so, because you cannot have—I don't know the American expression for this—we say, "On ne peut pas être juge et partie"—and the other side, "It cannot be judged."

The best example I know is my own government, the French Atomic Energy Commission, explaining as to its tests in the Pacific that it does a lot less harm than wearing a Swiss watch.

As long as the Atomic Energy Commission in any country is controlling itself, it will be wrong. As long as the countries who pollute are controlling themselves, their air pollution, it will be wrong.

We must delegate this control to an independent agency like, for example, it is done widely in the world for shipping. The American Bureau of Ships is not a government agency, it is a nonprofit organization. Lloyds in England also. So, why not apply to pollution, which is even more important than shipping, the same method that has been proved in the past?

I would like also to emphasize that in all the action to protect the environment may be an ignorance, or it may be for biased reasons, the good will of the people and mainly of the children are often switched to useless activities.

For example, on Earth Day, the only thing that was found to do for the kids was to pick up beer cans. There is a confusion in the minds of people between pollution which is deadly and litter which is inesthetic or inefficient.

One is very urgent; the other one is superfluous. We must put emphasis on saving the world from poisoning first. Then, we can make it beautiful. But then only.

I come here at the moment to switch the good will to the people against picking up beer cans.

There is a great hope inside for the control of the environment, and that is NASA's project Sky Lab, for the following reason: The high sea outside the national waters is outlaw country. Anybody can do anything or almost. The regulations about oil spills from tankers are or are not applied. God knows what happens when night comes. The chief engineers don't know what they are doing, because it is easier for them. Not all harbors are equipped.

So, I find hopes in the role of Sky Lab. You know that NASA has not found an adequate public support, probably because the man in the street dreams about the moon, about Mars, about outer space, to a degree, and he does not see in the long run what good it makes to him. People tell him that there are technological by-products. He couldn't care less. The man in the street wants NASA to be more in himself, and that is exactly what Sky Lab is going to do.

At long last space research is going to turn their eyes from outward to inward, and to look at our planet and to control and monitor it. Sky Lab to me is able, I know and I have discussed it with them, I know they have developed tools that enable them to measure from space the quality of productivity and pollution, temperature and currents. This is one thing, but productivity and pollution to such an extent that even a minute molecular hair on the surface of the ocean, left the night before by a ship, can be identified by a satel-

lite, analyzed, and by the nature of the oil it can determine, the cop responsible can be found out.

So, Sky Lab Two, not One, can become the police in outer space that we need to keep us in line and to protect future generations.

Senator HOLLINGS. Captain, thank you very much.

It is very exciting to contemplate the thought that while we are trying to withdraw as policemen of the world, we might end up as the environmental policemen.

I want to welcome Congressman Lennon here, the chairman of the Subcommittee on Oceanography of the House Merchant Marine and Fisheries Committee.

We are very glad to have you with us.

I am going to limit myself. Let me ask just this: suppose you keep on making pictures and we keep on talking and nothing happens. Twenty years from now, where will we be at this rate of ocean pollution? You say in the last 20 years, the best estimate you can give is that sea life has been destroyed at a rate of 30 to 50 percent, and this destruction is continuing on an increasing rate.

Let's say we do nothing, other than just talk and keep having hearings. What happens?

Captain COUSTEAU. The figure I gave is probably even optimistic. I have talked to the scientists, many of the biologists, and their latest findings seem to show that the rate of metabolism of carbon in living matter in the ocean is even much lower than was anticipated before, which would mean that by destroying the living stock in the ocean before it can be restored may take not a few years, but many thousands of years.

So, we are running into an entirely new field of understanding of the life cycle in the sea that has always been extremely fragile, and now that it is submitted to stress it collapses.

So, life in the set has always been fragile, it seems that the animals that have succeeded in going out of the sea and who have called on land, because of fighting over the difficulties they have encountered on land, have developed a strong resistance, and a strong resistance I think has been harmful to man, which is the most resistant of them all.

But when you return to the sea like whales and dolphins—for example, there are epidemics among animals like killer whales that make tremendous damage to the packs. They are found back in the progeny of the sea when they reenter the sea, it seems to me.

To answer your question, I think if nothing was done today, maybe 30, 40, or 50 years would be the end of everything.

Senator HOLLINGS. I was afraid you would say that.

You also testified that some 14 nations were responsible for about 83 percent of the pollution. Later on, I want you to give a list of those 14 nations to the committee. You think that is the way to approach it?

Captain COUSTEAU. I think so.

Senator HOLLINGS. But it has been measured that only 14 nations contribute about 82 or 83 percent?

Captain COUSTEAU. I can't remember whether it is 14 or 18 nations, but it is less than 20. This club of polluters could later on be enriched by nations that develop, and because of their development will join the club.

But at this time, I think it would be better first off to get results with a small number of fish.

Senator HOLLINGS. We only have a limited time since we have other distinguished witnesses.

Senator STEVENS. Captain, you mentioned this competition in the area offshore beyond the national jurisdiction. Have you ever taken a position on the extension of national jurisdiction for the purpose of concentration of pollution control, such as Canada did recently?

Captain COUSTEAU. No; because I have never seen yet, the proposal that would appeal to me. The only way to extend the joining of the States would be to take the earth, and divide it in equal parts and giving the responsibility—not equal parts but logical parts, and give the responsibility—not giving the sea to the nations, but the sea being the property of the United Nations as it has been decided, the United Nations gives a mandate to such and such nation, to shore-police in this area.

Senator STEVENS. I know you have been to my State of Alaska and made a very beautiful film concerning our salmon. We are quite worried along the lines that you have mentioned over this vacuum-cleaner type fishing gear that some of the large fishing nations are using in the North Pacific, and we apparently have no way at all to control it although we do control our own fishermen.

You said that you felt that out of the 1 percent of the money that is spent for marine research, and you estimated that to be about \$4.5 to \$5 billion, that the United States share would be somewhere around \$2 billion?

Captain COUSTEAU. A little less.

Senator STEVENS. I find it hard to believe in view of the impressive achievements of the economies of Japan and Germany today that almost half of the total load would be on this country.

Captain COUSTEAU. It is about what it is today. If you sum up the monies spent in marine research by all the countries around the world, you are spending about half of it. That is how it is today.

Senator STEVENS. I misunderstood your comment, then. You say that we are spending about half of the amount that is spent today. So, if it was increased to \$4.5 to \$5 billion—

Captain COUSTEAU. I extrapolated. Maybe it could be changed. But if it was extrapolated, it would mean for the United States a little more than \$2 billion, so I said a little less, in order to make a small change. But no less, it is so much more.

Senator STEVENS. One last question for me, you mentioned that you have been back to some place that you have been 20 years ago.

Captain COUSTEAU. Many places.

Senator STEVENS. And that in certain instances, you found specifications of increased pollution in terms of your activities. Could you tell us any one in particular that sticks in your mind?

Captain COUSTEAU. Certainly. For example, the simplest one for me because we see it every year is the Mediterranean. In the Mediterranean, shore-life has practically disappeared. It was very abundant when we started diving, and today you can barely see a fish 3 inches long and very rarely. Sardines are very rare and only in the area of Gibraltar. The factories are closing down. The price of lobster is skyrocketing because it is almost impossible to find.

Another example, Madagascar, that is a very remote place. The reef on Madagascar and also the Isle of Araba are frankly dead today. The Seychelles Isles in the Indian Ocean, also. We went there 15 years

apart, and we found a terrible difference. When we dive in the open ocean, for example, in the Sargassa Sea, where the water—I measured visibilities of a hundred meters in 1942 during the war, and recently we came back to the same area and we had hardly a hundred feet instead of a hundred meters, this is open ocean, far away from the coast, far away from any kind of normal introduction of minerals or earth.

What else? Well, I can give you examples of that sort all the time.

Senator STEVENS. Did you test any of those fish in the deep ocean for mercury by any chance?

Captain COUSTEAU. No; we don't. We don't because if we begin to measure mercury, why not cadmium, why not everything else, head, et cetera? So, I rely on the figures that come to me.

As you know, mercury is highly questionable. It has destroyed the lakes, right? But in the sea, I am not so sure that mercury is responsible for the accidents. After all, this is not a problem. Each time you want to put a finger on one cause. The aim is to eliminate all possible products from the effluents. That is feasible. That is Jack Davis' idea. Keep your toxic substances inside your fences. That is the only solution, whether it is mercury, lead, deterrents, everything else.

So, the technology may help. A certain part of the youth is very often accusing technology or the technological world as being responsible for its own destruction. That is not true. It is the misuse of technology. Technology is the only way to overcome the danger.

For example, I have been very interested in seeing experiments made in the United States and some other places to use the phosphates and nitrates from the effluents to filteralize areas, not only in the sea but on the land, and it works very well.

There are always ways of using for the good what is now used for the bad.

For example, the nuclear waste, I have not talked about that, but I could, it is a hot subject, let's face it, the manufacturers of nuclear plants claim, with some reason, that their plants are cleaner than the fossil fuel plants. It is true that it would be even more true if assurances were given to the public of what is done with the effluents and with the waste.

We know now that there are ways to dispose of it that cost a little more. So, who is going to pay for that little more? That is the only point. Whatever the cause, we always find out who is going to pay for that little more. That is the only question.

Senator HOLLINGSS. Senator Cook.

Senator COOK. Thank you, Mr. Chairman.

Captain Cousteau, before I ask any questions, I feel compelled to say that if 80 percent of the women in this country, and if 100 percent of the children, are very dedicated and have a strong desire to solve this problem, and would be perfectly willing to ask of themselves and of their Government to make this contribution, I feel that probably one of the greatest contributors to that has been your activities. I think in this regard, our country owes you a great deal of gratitude in regard to what our children and many grownups have been able to see, through your research and through your efforts.

I feel that everybody on this committee, and everybody in this room would agree with that.

I think one of the most amazing things that you said, and I would just like to repeat it, is that we have finally gotten to the point in the history of man where we are no longer in that long, hard, and arduous fight against mother nature, but we are now in a fight to preserve mother nature. This does take a degree of education, does it not, Captain?

Captain COUSTEAU. Yes.

Senator COOK. There has been no question about the fact that one of our prime responsibilities in the development of man, in the development of all of the things all of us in the world now use has been a dedication over the many, many hundreds of years to compete with mother nature and to conquer mother nature. What you are saying is that the real cure to the environmental problem is for us to understand that our job now is to salvage mother nature. We must now turn 180 degrees. Is that true?

Captain COUSTEAU. I would add to your statement, which is absolutely true, that we are facing a formidible enemy in this field. It is the hunters. The hunters are the peers of that known tradition, and they feel compelled to carry on the courageous fight of man against nature that was true for a million years, and to convince these people that they have to leave their gun on the wall is going to be very difficult—very difficult.

Senator COOK. Let me ask you one last question.

As we talk, I think one of the other remarkable things you said was that we should not delineate pollution. We should put one mark on it, and not segregate it into earth, air, and water, but understand that the recipient of most of it is the water.

Do you think one of the things we should also move toward is the consideration of legislation for the complete pretesting and preclearance of chemical substances before they are allowed to be introduced into the environment from the aspect of all three?

Captain COUSTEAU. I think we should be able to drink effluent and to breathe any agent. As long as we cannot do that, we are in trouble.

If the exhaust were containing CO<sub>2</sub>, we could take a bite of it without danger. But right now, the exhaust of cars can cause suicide. So, it is a good example of what we are putting in the air.

Senator HOLLINGS. You talked of Sweden and the United States. These other remaining 12 to 16 nations that are the principal polluters, what is their attitude?

Captain COUSTEAU. It varies. But it is coming with, I say, a time difference of 2 years, about 2 years. Japan and most of the European countries are following the path of the United States, but they started later. Japan has more of these problems than you have, and certainly realize it and there is a tremendous action in Japan now, a very recent one. They are going to make a strong effort, and they are willing to do so, providing competition is fair. It is always the same thing.

In Europe, as you know, Sweden is doing a lot, France has created a Minister of Environment, England just did create a Minister of Environment.

Canada has done so.

There is really hope that something can be done.

Russia—there is a question mark, because they have claimed—I remember in 1959 they claimed very hard that they would never dump nuclear waste in the oceans, and I think they have not done so. But

for the other fields, their attention against pollution which was pretty strong in 1955 to 1960 seems, according to the informations that I have which are scarce, to have dropped to a certain extent since the emphasis today is on Siberia. In Russia, everything is for Siberia.

I think that they have abandoned a little bit their position of strong antipolluters. But ideologically, they are obliged to be on our side.

So, I don't think it would be difficult to get them in.

Senator HOLLINGS. Congressman Shipley?

Mr. SHIPLEY. Thank you very much, Senator.

For the sake of time, I would just like to commend the gentleman for his statement, and I think all of us would agree that probably the biggest problem that we have is lack of research.

I think a very basic example that you gave in your testimony when you referred to the sea urchin, that right now the only solution we have is the more destruction to solve the problem.

I think this is a very good point that you brought out. I feel that the major pollutants, as far as the countries are concerned, the less than 20 that you said, need something that we have not had in the past.

I feel industry would be more than willing to cooperate. They have spent vast sums in this area, but I think we need some direction of beginning a program to solve the problem—just some guidance from these countries involved.

Do you feel this would be one of the main ingredients that we would need to solve this problem?

Captain COUSTEAU. I think that we are going to make mistakes, but we must act quickly.

I think the list of priorities should be revised according to the results of research. But without waiting, a list of priorities must be made now, and then revise them every year.

Mr. SHIPLEY. I also appreciate your remarks with regard to the Sky Lab, Captain. This is under my subcommittee on the Space Appropriations Committee, and frankly, I had never really heard any testimony from the space agency relating this project to the way you explained it today. I do appreciate this.

Captain COUSTEAU. I am conferring with NASA on the 22d, this Friday, about that.

Mr. SHIPLEY. I certainly appreciate talking with the gentleman.

That is all, Senator.

Senator HOLLINGS. Mr. Dingell?

Mr. DINGELL. My very good friend and colleague has to return to the House, and I ask that he be recognized before me.

Senator HOLLINGS. Certainly.

Mr. LENNON. I thank the distinguished Chairman for the invitation to hear our internationally known special guest today.

Did I understand you to say, sir, during the decades of the fifties and sixties, there were a substantial number of oceans endangered species that became extinct?

Would you recapitulate, or give that figure for my memory, give a ballpark figure?

Captain COUSTEAU. This encompasses all species, not especially marine species, species that disappeared from the earth.

It is a Russian study from a Russian behaviorist that was published in English. I don't have the reference here today, I am sorry. But I

studied this 4 years ago, and it gave the curve and the number of animals and the name of the animals that have disappeared from 1900 to 1960.

From this study, which was very serious, I have on my own speculation made a curve, because there were a number of dates in the paper, I made a curve of how, how it was going up. It means that every year more species were eradicated.

It was frightening. Birds, mainly.

Mr. LENNON. Did they by any chance include any of the species of marine animals, mammals?

Captain COUSTEAU. There are not many mammals that have actually disappeared.

Mr. LENNON. The curve is still that way at this point in time?

Captain COUSTEAU. I beg your pardon?

Mr. LENNON. The curve is still in the direction, we are still losing?

Captain COUSTEAU. For some species, we are losing.

For others, we are gaining. Gray whales are coming back very well.

Mr. LENNON. What nations are there in the world of the 14 to 18 that you described as being the greatest contributors to ocean pollution, have laws which specifically prohibit certain types of ocean dumping or either transporting from the Nation's shores certain types of materials to be dumped in our oceans?

Captain COUSTEAU. To my knowledge, none has any serious such.

Mr. LENNON. I assume you know that legislation has been passed by one of the branches of Congress, very definitive and strong legislation in that direction. Are you familiar with that legislation?

Captain COUSTEAU. I am not quite familiar with it.

I have heard of it as well as the action taken by 17 States in this country, et cetera.

Mr. LENNON. As one of the 18 nations which will move in the direction, won't this cause the others to move strongly to prohibit ocean dumping?

Captain COUSTEAU. I think I said so.

I agree at the moment that the United States is not doing enough, but it is doing more than the others.

Mr. LENNON. We are not doing enough until we pass strong legislation.

Senator HOLLINGS. Mr. Dingell.

Mr. DINGELL. I want to thank you very much for the courtesy that has been extended to me today, and for the privilege of being able to participate in this meeting.

I also want to commend you for what you are doing here today. My good friend, Congressman Lennon and I came over here with a matter of particular interest. I would like to join him in expressing concern over H.R. 9727, which in our view is a rather fine piece of legislation, dealing with the dumping of materials into the oceans, coastal and other waters, and for other purposes.

Mr. Lennon and I, and our staffs, and our colleagues in the House, have put literally hundreds of hours into developing what we regard as the best possible piece of ocean pollution and ocean dumping legislation.

I was particularly interested to hear Captain Cousteau allude to the need for research into the overall health of the oceans, and I was

pleased to note that we had anticipated his concern on that point by providing a research section.

Of course, we have provided in addition to that, in addition to the dumping section, and that section just alluded to a very fine section related to authority for the Secretary of Commerce acting in his capacity as the chief officer of the department in which he exists, appropriate provisions for the establishment of marine sanctuaries, areas of particular ecological and environmental concern.

Captain, I have been long an admirer of yours, the very distinguished work you are doing in this area. I just wanted to ask what might be a question that might tend to bring the matter closer to home.

You have expressed general concern over the overall welfare of the oceans. I think perhaps we might bring the matter a little closer to home by taking a look at some of the major bodies of water that have, for all intents and purposes, ceased to be of ecological and environmental value.

The Black Sea, as I understand it, became a dead sea about 4,000 years ago.

I understand that now both the Baltic and the Mediterranean are anticipated to be in the same kind of trouble, whereby conceivably by reason of pollutants and damage of that kind, they might perhaps die very shortly.

Do you have a comment you would like to make on that, sir?

Captain COUSTEAU. I fully agree. The Black Sea is dead below the level of the Bosphorus Straits. In the upper layer there is some life because water is flowing into the Black Sea from the Mediterranean as well as the Atlantic water is flowing into the Mediterranean. So there is a refertilization of the Mediterranean first by the Atlantic, and in a much lesser degree, of the Black Sea by the Mediterranean.

Nevertheless, what is happening now is under the level of the Straits of Gibraltar for the Mediterranean, and the Bosphorus for the Black Sea and for that matter, for the Red Sea. Below the depth of these three straits, there will be nothing alive anymore.

I made hundreds of dives with exploration submarines in the Red Sea, and there is practically nothing left.

The Mediterranean is the same thing, and the Black Sea, it is done already.

So, yes, we are faced with that type of thing. If the surface of these seas were dead, the pestilence would raise up, and people would have to abandon the coastline for many months. It would be unlivable. So the only thing that avoids the seas from becoming infested, is life.

Mr. DINGELL. Captain, there is another matter that I think you might address yourself to.

I understand there are two conferences, international conferences next year relating, one to mammals and, two, to the general condition of the ocean seas.

I wonder if you would like to give some suggestions, perhaps through this gathering today, to those two meetings with regard to steps that could or should be taken by nations generally and internationally, to protect the sea and to protect the living resources of the seas?

Captain COUSTEAU. My opinion on this is that—it is only an opinion—my opinion is that legislation is not—international legislation is not going to come from the conferences. The conferences that you are

talking about are going to bring in information, bring in discussions, and the resolutions that will come about will be meaningless, as usual.

Nevertheless, they will bring in a lot of very useful information so that the ministers of a small number of nations can elaborate something that has sense.

I do not believe that the conference can come about with an enlightened proposal. I do not believe it. I think that this belongs to the leaders in small numbers.

Mr. DINGELL. Mr. Chairman, thank you very much for the courtesy.

Senator HOLLINGS. Thank you very much, Captain Cousteau.

I have had the pleasure of listening to witnesses for 5 years in the Senate and 20 years before making a living, and you are the best-rounded witness I have heard. I am sure this committee could really examine you with benefit throughout the entire day. We will excuse you now.

The next witness will be Mr. Mark Morton, Vice President and Group Executive of the General Electric Corporation.

Mr. Morton, you can come forward.

I am going to make your biographical sketch a part of the record. Suffice it to say it is one of the most outstanding in the field of aerodynamics and engineering, and I know you personally as being one interested in the ocean, an expert diver in your own right, and that your company is environmentally concerned.

This committee wanted to have a spokesman from one of the large American industries that is environmentally oriented and concerned, particularly as regards pollution and the development of technology and the challenge being given technology at this time.

Mr. Morton, we welcome you, and we will be delighted to hear from you at this time.

(The biography follows:)

#### BIOGRAPHICAL SKETCH OF MARK MORTON

Mr. Morton is a Vice President of the General Electric Company, and is the Group Executive of the Company's Aerospace Group, comprising five Divisions and 40,000 people.

Mr. Morton was graduated from New York University with a degree of Bachelor of Science in Aeronautical Engineering, and received a degree of Doctor of Engineering (Hon.) from Rose Polytechnic Institute.

Mr. Morton joined the Philco Corporation after graduation and later served as an aeronautical engineer with the Engineering Division of the U.S. Naval Aircraft Factory, Philadelphia, Pennsylvania, as a designer of aircraft and aircraft engines.

From 1937 to 1939 he was self-employed as a consulting mechanical engineer in the development of electro-mechanical devices and special instruments. He then returned to the Naval Aircraft Factory serving as an aeronautical engineer, performing aerodynamic investigations. He was later promoted to Supervisor, Experimental Design Group, engaged in the development of pilotless aircraft and guided missiles.

In 1944, Mr. Morton was transferred to the U.S. Naval Air Modification Unit, Johnsville, Pennsylvania, later renamed the U.S. Naval Air Development Center, serving in the position of Head of the Airplane Design Section of the Engineering Division, where he received a personal commendation from the U.S. Navy for outstanding service during World War II.

Continuing his service at this U.S. Naval Center, in 1948, he was appointed Head of the Airframe Branch of the Pilotless Aircraft Development Laboratory, and in 1951, he was promoted to Chief of the Engineering Division of the Engineering and Development Services Department, responsible for the design, development, testing, and evaluation of special aircraft, pilotless aircraft,

guided missiles, and a wide variety of mechanical, electro-mechanical, and electronic devices and systems.

In 1956, Mr. Morton joined the General Electric Company, Missile and Space Vehicle Department, Philadelphia, Pennsylvania, as Manager, Project Planning and Review, for the Mark 2 and related re-entry systems programs for Thor and Atlas. He was appointed to the position of Manager of Projects in 1958, and Manager of the Re-entry Systems Product Section in 1961, responsible for the program management of such programs as the Mark 3 and related research and development and operational re-entry systems for Thor and Atlas; research re-entry recovery systems; recoverable satellite re-entry systems; space power systems; and tactical missiles.

In 1962, Mr. Morton was appointed General Manager of the Re-entry Systems Department, Philadelphia, Pennsylvania, adding to the foregoing such research and development and operational re-entry systems programs as the Mark 6 for Titan II; the Mark 12 for Minuteman II and III; research and target re-entry systems; and Biosatellite and special satellite recovery systems.

In January, 1968, Mr. Morton was appointed General Manager of the Missile and Space Division, with headquarters in Valley Forge, Pennsylvania, responsible for development of space and re-entry systems, and related integration and support, on such programs as Nimbus, Apollo, Manned Orbiting Laboratory, Re-entry Systems, Recoverable Satellites, and associated scientific and technological developments.

He was elected a Vice President of the General Electric Company in the year of 1968, and in June, 1969, Mr. Morton was appointed to his current position as Group Executive, Aerospace Group, General Electric Company. In this capacity, in addition to the space and re-entry systems just described, his responsibilities include Aircraft Control and Instrumentation Systems; Airborne and Ground Radar Systems; Earth Resources, Environmental and Communication Satellite System; Environmental Technology; Socio-Economic Systems; Urban Housing Systems; and Ocean Systems. His Aerospace Group comprises the Space Division, Re-entry and Environmental Systems Division, Aircraft Equipment Division, Electronic Systems Division, and Aerospace Programs Relations Division. He has received the NASA Public Service Group Achievement Award in 1969 in connection with the historic flight of Apollo 11.

Mr. Morton has received many awards for his work in community affairs, urban problems, and small business support, such as the Federal Bar Association Award in 1967 for his work in community and youth education programs; the Philadelphia Cotillion Society Award in 1967 for his efforts in behalf of disadvantaged youth; the NEMA Award in 1968 for his work with the schools and minorities; and the Small Business Administration Award in 1969 for his leadership in developing community programs and minority-owned small business. In 1970, he received a commendation from President Nixon for his outstanding leadership on social and economic problems and his efforts to provide full opportunity to all Americans.

Mr. Morton is an Associate Fellow of the American Institute of Aeronautics and Astronautics, and a member of the American Ordnance Association, the Armed Forces Communications and Electronics Association, the Air Force Historical Foundation, the National Space Club, the American Astronautical Society, the Association of the United States Army, the Air Force Association, the Navy League, the Electronics Industries Association, and the National Security Industrial Association. He is member of the New York Academy of Sciences, and of the Science Advisory Committee of the Alabama Space and Rocket Center. He is Chairman of the Board of the Sea Space Symposium.

#### **STATEMENT OF MARK MORTON, VICE PRESIDENT AND GROUP EXECUTIVE, GENERAL ELECTRIC CO.**

Mr. MORTON. Mr. Chairman and members of the committee:

I want to say at the outset that it is a great honor for me to join with such dedicated pioneers as Jacques Cousteau and Scott Carpenter, under the auspices of Senator Hollings' Subcommittee on Oceans and Atmosphere, in expressing my views on how to make wise use of the ocean while preserving the integrity of that environment.

I have a deep conviction that substantial economic and social bene-

fits can be realized by developing our ocean resources, improving ocean transportation and trade, and successfully competing in the world market. At the same time, it is essential that we consider the problems of pollution which have accompanied our efforts to exploit resources and expand trade; therefore we must plan our ocean program to safeguard against further ecological damage, as well as to make lasting improvements in the quality of our ocean environment.

My concern about our ocean program is based on many years of personal interest and involvement with ocean development. My company (General Electric) has, for a considerable period of time, been developing and manufacturing a diverse range of ocean products such as marine turbines and ship propulsion drives, nuclear submarine power plants, sonar systems, equipment for the offshore petroleum industry, advanced diving equipment, undersea laboratories, ocean data buoys, shipboard waste pollution treatment equipment, and oil pollution treatment equipment. This experience in oceanic work, as well as in a high-technology aerospace business, has provided some valuable insights about the necessary ingredients for successfully implementing a broad national ocean program. I would like to share these insights with this committee.

It was just 10 years ago that the National Academy of Science and the U.S. Navy focused attention on the importance to the United States of oceanic activities and marine resources. Since then, we have witnessed a rapid development of ocean technology. Man has increased the depth of a suitably equipped free diver from 200 to 1,000 feet in the sea and to almost 2,000 feet in a chamber; he has lengthened his stay in the sea from hours to months by use of undersea habitats and laboratories. Deep submersibles have explored the continental shelves and touched the bottom of one of the deepest ocean trenches. Offshore oil supply has steadily increased and presently provides 18 percent of the U.S. demand. Exploratory oil wells are now being drilled in more than 1,600 feet of water, and undersea production systems are being developed to operate in 2,000 feet of water. Containerization has provided considerable progress for the shipment of cargo, and the world's tankers have grown in size from 70,000 to 400,000 tons.

In conjunction with this progress, we have also witnessed an increasing degradation in the quality of the marine environment because of contamination from oil spills, pesticides, industrial pollutants, and shipboard and municipal wastes. Clearly, we have not taken full advantage of our technological capabilities in attacking marine pollution. I will have more to say about this later.

Recognizing the national need, Congress enacted the "Marine Resources and Engineering Development Act of 1966" and as a result a Commission was formed to draft a national plan for the wise use of the sea. Under the able leadership of Dr. Julius Stratton, the Commission submitted, in 1969; to the President, the Congress, and the Nation, a report titled, "Our Nation and the Sea." The strength of the Commission report is in its breadth of conception, and its usefulness and relevance today is as great as it was 2 years ago.

Subsequently, in 1970, the Reorganization Plan No. 4 established the National Oceanic and Atmospheric Agency (NOAA) within the U.S. Department of Commerce.

NOAA was created to improve man's comprehensive use, and preservation of the ocean's physical environment and its living re-

sources. I believe that these three purposes, understanding, using, and preserving the ocean, should be balanced in the best national interests. From this view, understanding the ocean consists of research and exploratory studies to establish a base of knowledge about oceanic life, physical and chemical processes, ocean-atmosphere interaction, and the mechanisms of marine environmental pollution; using the ocean involves a national assessment of marine resources and their distribution, and the development of tools and techniques to improve the extraction and recovery of oil, chemicals, minerals, and the harvesting of living resources for food and medicine. Future uses of the ocean include extraction of energy and the establishment of communities on the surface of and under the sea. Preserving the oceanic environment consists of the development of technologies, equipment, and management techniques to prevent and reduce damage to the physical and biological environment of the oceans and the coastal zone from the deleterious effects of pollution as well as from such destructive natural events as hurricanes and tidal waves.

The funding to NOAA is woefully insufficient, and this is delaying the initiation of projects needed to acquire a basic understanding of ocean processes and the mechanisms of pollution. There are similar serious deficiencies in the national programs for using the ocean and preserving its environment. Recognizing these financial inadequacies, remedial steps were presented in Bill S-1986, "A Bill to Foster a Comprehensive, Long-Range, and Coordinated National Program in Marine Science, Technology, and Resource Development, and for other Purposes," introduced by Senator Hollings. Implicit in the bill is the understanding that wise use of the ocean will require a partnership of government, universities, and industry in a rival new program.

To obtain a better perspective of the present state of marine affairs, one must understand that we have truly entered an era of internationalization of resources. The human and natural resources of all nations have become economically available. For example, through marine transportation, iron ore from Peru or New Zealand together with coal from Austria and Canada, and oil from the Persian Gulf and Indonesia, are all utilized to make steel stock and plate in Japan for building the World Trade Building in New York City.

Mr. C. W. Robinson, president of the Marcona Corporation, one of the largest suppliers of iron ore to Japan, has referred to an "illusion of distance" in making the point that using large ocean bulk carriers and modern technology substantially reduces the cost of marine transportation in comparison with land transportation. Hence, with 130,000 ton bulk carriers and suitable loading facilities, Brisbane and Tokyo are closer to Los Angeles in cents per ton-mile than is Fresno, California. The use of large ocean carriers and the construction of deep port and harbor facilities have contributed substantially to the soundness of Japan's "island economy" through the internationalization of resources.

In addition, one must consider the huge financial and human resources of large multinational corporations, in order to visualize the world marketplace in which the U.S. must compete.

Against this background there are many promising areas in which the Nation could become engaged, such as food sourcing; transportation, mining, oil, necessary research, and recreation which is itself

a very large and attractive field. I have selected and will examine three oceanic projects which promise to have a profound influence on U.S. employment, economy, resource utilization and environmental quality. They serve to highlight the key concepts I wish to express concerning the formulation and implementation of a strong national ocean program. The three projects are: (1) the timely development and use of liquefied natural gas carriers; (2) the development of large, multipurpose offshore platforms, and (3) the large-scale monitoring of the ocean environment, leading to its proper management and control.

The role of liquefied natural gas (LNG) in the world energy market is projected to grow rapidly in the seventies. This growth is dependent upon the availability of the special ships and terminal facilities required to transport and store the gas (as a cryogenic fluid for minimum bulk). Present annual demand for gas in the United States exceeds the supply. If the demand continues to grow at a projected average annual rate of 3.2 percent, a domestic shortage of twelve trillion cubic feet of natural gas will result by 1980. This shortage, equal to almost one-half of the present domestic supply and equivalent to 12 percent of the projected total U.S. primary energy consumption in 1980, must be obtained from foreign sources. The surge in the use of natural gas is due to this relatively pollution-free characteristics, the availability of gas transmission systems in the U.S., and the fact that changeover from coal or oil to gas-fired systems is simple and inexpensive. Additionally, the petroleum-producing countries of the world are no longer willing to flare gas from oil wells. Many of these nations are introducing laws that require the storage or the reinjection of the gas into the well.

The means for adequately economical ocean transportation of such large quantities of gas do not exist in the world today. There are currently LNG tankers. However, new LNG ships must be built that are larger and faster. Because LNG tankers must be capable of containing the liquid gas at minus 259 degrees Fahrenheit for volume reduction, they must be equipped with special cryogenic tanks, pumps, compressors and piping, in addition to new and efficient propulsion and reliable navigational systems. In the U.S., the needed technology and trained personnel are available. However, there is a lack of national commitment to this goal, essential to the transfer of technology and personnel into a competitive shipbuilding program. Presently the lead for the new LNG tankers has already been taken by other nations.

Almost two decades ago, Dr. Hisashi Shinto, Executive Vice President of Ishikawajima-Harima Heavy Industries Co., Ltd. (one of the world's largest shipbuilders), was assigned the responsibility for reorganizing the Japanese shipbuilding industry. For their major shipbuilding accomplishments which followed, considerable credit was given by Dr. Shinto to the National Bulk Carriers Corp. of the United States for introducing into Japan American technology and efficiency for building ships on a standardized mass-production basis. In addition to the funding of technology, Japanese governmental subsidy was obtained to insure the continued growth of their shipbuilding industry. Mr. C. W. Robinson has pointed out that the subsidy is in the form of special low prices for ship construction steel, combined with attractive sales financing provided by the government.

As with mass-production shipbuilding, the United States has the technology, materials and trained personnel in the relatively new field of cryogenics. The space program and other industrial applications of liquid gases have established the technological base. However, the application to these new larger, faster LNG carriers is being left to other nations such as Japan, France, Norway, Sweden, Italy, and Spain. The opportunity to apply this technology to the construction of LNG carriers is especially attractive to the United States because of the size of our domestic demand for LNG. Because the new LNG ship is highly sophisticated and new technology and expensive materials are used in construction, the total ship cost is less sensitive to labor rate differentials. Projections indicate that by 1980 34 LNG carriers of 120,000 cubic meters capacity will be needed to service the United States, at a cost of between \$80 and \$100 million per ship. Adding to this cost the capital expenditures required for LNG plants, terminals, and storage, the total U.S. investment in the 1970's would be about \$6 billion over about 10 years. The projected size of this effort offers tremendous opportunity for large scale employment of both technical and nontechnical workers.

The second major ocean development expected to emerge in the seventies is the construction of large offshore platforms or "islands." Use of these offshore facilities has been considered for deepwater port terminals, and as a solution to geopolitical siting problems for powerplants, airports, industrial centers and, ultimately, complexes of these services. The pressures of population growth, industrial expansion, and pollution are now forcing coastal communities to look offshore for relocating many of their land-based facilities.

Construction of offshore deepwater ports and terminals would enable us to handle giant containerships and supertankers, thus greatly improving the U.S. competitive trade position. There are about 700 large vessels in the world that have drafts too deep to enter U.S. ports. Our two "deepwater" ports at Long Beach and Seattle are the only U.S. ports that can accommodate 100,000-ton vessels. In other countries there are 50 harbors than can handle 200,000-ton vessels. Because of the high costs and the disruption involved in deepening and widening channels to our existing ports, the offshore man-made island concept is rapidly gaining favor.

Other uses for man-made islands might include sites for industries requiring large amounts of cooling water, such as chemical plants, powerplants, and oil refineries. The ocean can easily dissipate the waste heat without significant ecological damage. In addition, offshore powerplants can provide coastal cities with desalination as well as energy. Major industrial contributors to urban pollution and noise, such as refineries, chemical plants, and airports, could be moved offshore in order to "clean up" and beautify the urban environment and make the cities a healthier place to live. The plan for moving these industries offshore should provide for the eventual incorporation of highly effective effluent and waste handling systems to control pollution of the ocean, and to eliminate the possibility of atmospheric contamination being brought back to coastal cities by prevailing winds.

Large-scale offshore projects will provide gainful employment to those in the under-utilized urban labor force of the coastal megalopolis. Today 86 percent of the country's population lives in the coastal States, and 43 percent live in the counties bordering our coastlines.

Clearly, national priorities for ocean development should emphasize the needs and desires of these people to improve their quality of life and economic well-being. The problems of urbanization, caused by rapid shifts in population distribution, are destroying the city and dehumanizing its inhabitants. Instead of fulfilling their potential and contributing to the economy, many are frustrated by a lack of employment. New jobs would be rewarding to them, not only economically, but also in the knowledge that they were contributing directly to the betterment of their own living environment. The benefits will be an increased flow of dollars into the economy and the improvement in the quality of the environment.

It is not too soon to begin the necessary engineering and develop the specific plans for such a bold new program. Many of the technological skills and the manpower are now available. The Government should take the lead, in partnership with industry, the universities, and the scientific community, to turn this concept into reality. To accomplish this, a commitment must be made to finance some of these large offshore undertakings and the necessary supporting technologies. By step-wise growth, island complexes with a multiplicity of purposes can evolve which will be competitive with existing onshore facilities and will enhance our Nation's overall position in the world marketplace. In several countries, man-made islands are in the working, and are considered the wave of the future.

A third major ocean project is the deployment of ocean environmental surveillance and monitoring systems which would lead to the management of the ocean environment. These systems would assess the "state of health" of the oceans and the coastal waters, detect pollutant levels, mechanisms, and distributions, and monitor and predict natural environmental phenomena of weather patterns and storms. One such worldwide program presently underway is the Integrated Global Ocean Station System (IGOSS), being coordinated through the Intergovernmental Oceanographic Commission in cooperation with the World Meteorological Organization. NOAA's National Buoy Project is contributing to IGOSS by the development of data buoy technology and determination of system requirements. Both IGOSS and World Weather Watch are the beginnings of a coordinated global monitoring system.

Similarly, the United States must coordinate and expand its environmental monitoring by utilizing advanced sensors, communications and data processing technology. Effective action requires increased deployment of data buoy stations in coastal regions, combining pollutant detection with oceanographic and meteorological measurements in the same ocean station and integrating these ocean data sources with ship data and remote sensing information from aircraft and satellites such as the Nimbus Weather Satellite and the Earth Resources Technology Satellite.

The use of submersibles and undersea habitats and laboratories should complement the other information and observational platforms. As Jacques Cousteau has proven in his pioneering Conshelf experiments, man's personal observations can provide knowledge about the health and nature of the ecosystem which instruments cannot supply. The importance of this fact was further demonstrated in our TEKTITE project where many months of continuous scientific work were accomplished. The combination of man-in-the-sea programs

with instrumented monitoring stations will enable us to achieve a more nearly complete understanding of ocean environmental processes, their management, and their effect on all living things.

Many environmental data systems are being used by NOAA and NASA, but a truly cost-effective, coordinated system has yet to be implemented. With a greater financial commitment to this purpose, and a more centralized focus for coordination of the many parallel programs now being pursued, our Nation should eventually be capable of not only controlling ocean environment pollution but also managing the control of some natural disasters, such as hurricanes, and operating warning systems for tidal waves and earthquakes.

The technical skills and trained personnel of the aerospace industry are available for application to this endeavor. There is much commonality between aerospace and ocean systems technologies. Central integrative program management, as well as capital investment, on the part of the Government is needed to foster the constructive application of these technical resources.

Traditionally this Nation has maintained a competitive lead through technological superiority. Today, however, we are witnessing a serious attrition of engineers and scientists in this country. This is partly due to space and defense cutbacks which are driving many technical people into nontechnical professions. Probably of equal importance is the fact that young people today are less attracted to engineering than they were a decade ago, and this trend is shown in the proportion of applications to engineering colleges. The effects will be felt acutely later in the decade, when technological stagnation could set in, unless something is done about the situation. The stimulus to our youth provided by a challenging and socially relevant ocean program, and the rewarding job opportunities it would offer to our disenchanting and poorly utilized engineers and scientists, could reduce the projected losses of these valuable technical people.

In conclusion, I have presented my thoughts on the future of our Nation's ocean program by discussing three promising projects that we should undertake and their potential impact on the economy, resources and environmental quality. There are a number of common threads and synergistic relationships among these projects which convince me of their viability and importance.

One of these is the long-range benefits that will accrue through improvement in our ocean resource utilization.

Another common thread is the enhancement of transportation and trade which places us in a better competitive position in the world marketplace.

A third is the provision of enhanced employment opportunities and training for our Nation's work force in general and our skilled technical personnel in particular, and the additional dollars that this will bring into the economy.

A fourth common element in all of the recommended projects is the opportunity to utilize many of the advanced technologies already developed, and reapply these to solving our pressing ocean problems.

A fifth is the incentive to cooperate with other nations on many aspects of these ocean projects and the resultant stimulus to international technical exchanges, improved relations and increased trade.

Finally, all three projects address themselves in large measure to the long-term alleviation, in fact, reversal, of environmental degradation.

These approaches offer far-reaching solution to the problems of a high quality environment, instead of temporary "fixes."

To implement this expanded ocean program in such a manner that real economic payoffs can be realized within a reasonable period, requires that detailed objectives, plans and priorities must first be established. Then they must be followed by the commitment of sufficient funding to carry programs through development, pilot demonstrations and full-scale operations. The Government must provide the necessary management impetus and capital investment in the critical technologies and pilot projects in order for industry to have the incentive to follow through in a cost-competitive way with assurance of a reasonable return on its investment. The Government undertook a major capital investment in satellite communications development during the last decade, building on the large investment already made in rocket booster technology. As a result, commercial communications satellites are operating today on a cost-competitive basis. This achievement would not have been possible without the Government's initial investment in these technologies.

A reduction in research and development expenditures by the Federal Government, in terms of both uninfated dollars and percent of GNP, has been in effect from 1967 to 1971. Whether this reduction indicates a basic shift in overall priority assigned to R. & D. in the Federal Government, or whether it includes the result of redirecting previous emphasis on space, defense, and atomic energy, the portent of this trend signifies the beginning of a period of technological stagnation, with a resultant weakening in our Nation's world-competitive position. We must reverse this trend soon if we are to retain our technological superiority, and we must reorder our priorities into economically and socially rewarding channels. I believe the three ocean projects I have described will produce considerable momentum toward achieving these goals.

We stand today at the threshold of very exciting possibilities for ocean exploration and development. We possess the capabilities and, hopefully, the wisdom to utilize this environment, its food, its energy sources, its materials, and its recreational values for the betterment of mankind. At the same time we must protect the balance of the ecosystem from further degradation. Industry is ready and willing to commit its resources and capabilities to the challenge that lies ahead. It is my sincere hope that industry, universities, the scientific community, and the Government will be able to move forward in partnership in building a truly constructive and urgently needed national ocean program.

Senator HOLLINGS. Mr. Morton, that is a very excellent statement. It certainly outlines the factual matter of the challenge before us.

We are going to want to hear from Scott Carpenter and Mr. Christian Herter before lunch, so I will be very brief and just ask this one question: From the standpoint of the development, you say that the Government must fund a national oceans program. Isn't it a fact that other governments are doing just that? The Japanese, for example? What are they doing?

Mr. MORTON. It is a fact that other governments are funding their ocean programs. As a matter of fact, other governments are doing it so vigorously that we find American industry involved in support of other countries.

For example, in the case of my own company, we are already involved in doing much work with other nations. Inasmuch, Mr. Chairman, as you have mentioned Japan, we have just signed an agreement with the Mitsui Ocean Development and Engineering Co., for supplying ocean systems technology. In other words, we are already involved with the Japanese Government and with other governments more than we are with our own.

Senator HOLLINGS. If the United States doesn't do business, you will do business with Japan, is that right?

Mr. MORRISON. That's about right.

Senator HOLLINGS. What about the matter of technology with respect to pollution, the actual drilling, the design of oil tankers and everything: isn't there an improvement in technology along this line to protect the environment, and we're not doing anything about it?

Mr. MORRISON. The technology, in my view, is available. There are a lot of people that know technology. We have the resources. But we are certainly not making adequate use of them. We have no coordinated program in this country to bring all the resources together.

As Jacques Cousteau pointed out, our efforts should be brought together in concert with other countries. I think the U.S. Government has to take the lead in this to begin to bring together a program of international cooperation.

Senator HOLLINGS. The fact is you also, in another capacity, are Chairman of the Board of an organization which is deeply concerned with the oceans and whose members often examine the underwater environment first-hand.

Isn't it a fact that this organization has difficulty in locating diving sites that are not polluted?

Mr. MORRISON. You are referring to Sea-Space Symposium, which has as a purpose the advancement, in the public interest, of the mutual sciences of hydrospace and aerospace. Its members are outstanding contributors to those fields. It is hoped that the frontiers of ocean exploration will be advanced by the transfer, where commonality exists, of space technology to ocean application. The members do from time to time personally observe major undersea programs, such as TEKTITE and AEGIR. It's true that a pollution-free environment for such programs is difficult to find.

Senator HOLLINGS. Senator Stevens?

Senator STEVENS. I enjoyed your statement very much.

Is your company paying a portion of this arrangement with the Japanese, or are they financing it?

Mr. MORRISON. No, it is being financed by the Mitsui Ocean Development and Engineering Co. The Japanese Government does a lot of work in partnership with their industry, and when their industry gets into a new field, it is done with a great deal of Japanese financing.

Senator STEVENS. I wonder if General Electric would like to help us educate the U.S. Chamber of Commerce on some of those aspects?

Senator HOLLINGS. The U.S. Chamber of Commerce and the U.S. Government. There is the old argument around this body about free trade. Yes, we could always have free trade and compete as long as we had a superiority in technology, but as you indicate in your testimony, now the United States during the past decade has been selling its technology, which has developed new jobs, and that is why we are

seeing 10-percent surcharges in order to get our trade picture back into balance.

I wish we had time to go into that.

Senator STEVENS. We could go into that for a long time.

Senator HOLLINGS. Mr. Shipley?

Mr. SHIPLEY. Thank you, Senator. Just one observation and a question: The point that bothers me in listening to this testimony today, and I think all of us would agree, that now is the most emotional time this country has ever had with the environmental problems we have concerning pollution. You mention on page 6 of our statement that some countries were now enforcing the gas laws on oil wells so that they have to inject the gas back into the storage rather than burning it off as they have in the past. This bothers me in that I do come from an oil State, and we have a very difficult time, of course, in competing with other countries.

The thing that bothers me with the environmental program is that we may go too fast, too strong without a combined effort of all of the polluting countries, that we will pass laws that would force unfair restraints on American industry by coming up with strong pollution laws and strong enforcements.

This is a very important point.

The one question I would like to ask you, Mr. Morton, I think it is common knowledge that this country has not invested as much as we possibly could in the past, and are not doing so presently. My staff is at the present time attempting to work out a bill that I can introduce that would offer some type of tax incentive for industry to go ahead and invest more than they have in the past. I just wonder if you might have any comments on what you think of this type of bill? It is something similar to the oil depletion allowance. We think the ocean is one of our great natural resources, and everyone who has talked today tells us that we are destroying one of our greatest natural resources. And I see nothing wrong with setting up some similar legislation as I have mentioned.

Would you give your thoughts on that?

Mr. MORRIS. This is a very touchy subject, as you gentlemen know better than I. Other industrial nations place a higher priority on international trade than we do. Other nations provide incentives for investment that put the United States at a disadvantage relative to our foreign competition.

Foreign governments use investment credit type allowances and accelerated depreciation policies to reduce income taxes for the purpose of encouraging capital investment, and to provide an incentive for the renewal and modernization of factories. The purpose is to increase productivity, lower costs, and thereby stimulate export business.

As a nation, we do not have a cohesive economic policy. Nor do we, as other nations do, examine proposed changes in our domestic policy from the viewpoint of impact on our international trade.

Mr. DINGELL. Senator, again I want to express my gratitude to you. You have been most gracious to me. I thank you.

I have no questions. I have read Mr. Morton's statement with care while I was on the way over. It is an excellent one. I am very pleased with it.

Senator HOLLINGS. Since we got a little off, Mr. Morton, from pollution jobs and the challenge, specifically that is exactly why we

introduced S. 1986, to use the money available to put the space technicians and engineers and scientists into this research and into the development of the oceans from the space field.

Last week Senator Stevens and myself were in Seattle. There are 180,000 unemployed in that area—technicians, scientists. Wilbur Smith of the AFL-CIO testified that they could transfer very easily into this same field.

The Senate, on August 6, voted a billion dollars, but not to get into this field, not to take those truly unemployed and put them in a field in which they can associate with, but to put them in the courthouse and the statehouse, and to pick up the trash in the parks. That was the testimony before our Appropriations Committee.

We could take them all and let them all get in the courthouse and clean up the parks, and as I said, pick up the trash. Here is the challenge going by, and the other countries moving in this field.

We appreciate very much your testimony here this morning.

Mr. Carpenter, we appreciate your being here with us. I will never forget after his three orbital flights he was asked how he felt in this blastoff, and he said "How would you feel going 100,000 miles in the air at something like 1,700 miles an hour and with about 22,000 moving parts, all of them made by the lowest bidder?"

I told that to Senator Proxmire, and it didn't move him a bit.

Mr. Carpenter, your fame has preceded you both in space and in the ocean depths, and you will make a very valuable contribution.

#### **STATEMENT OF SCOTT CARPENTER, FORMER NASA ASTRONAUT**

Mr. CARPENTER. Thank you, Mr. Chairman, and good afternoon. You may be pleased to know that I shall attempt to be brief.

Unplanned but referring to your story, one of the reasons we gained the ultra reliability of the manned shots, particularly the Atlas and Redstone, is that we insisted that the blockhouse for the launch crew used for the manned shots be made only of canvas.

Let me begin, if I may, with a brief history of my involvement with the ocean. It began academically with Captain Cousteau. I followed very carefully everything he wrote and filmed and did in the ocean for many years.

My involvement with NASA and my understanding of the machines and the equipment that are required to support men in space made it apparent to me that NASA technology had great transfer potential for exploration of the sea.

After securing permission from Dr. Gilruth at the Manned Spacecraft Center, I visited Captain Cousteau at MIT and asked him if there was any interest in my acting as liaison between his "Man-in-the-Sea" program and our own "Man-in-Space." He said that that might be worthwhile, but if my interest was only in bringing NASA technology to the ocean, by far the simpler way to do it was with the U.S. Navy program.

I was not aware of it at that time, but it was through that discussion that I finally met Captain George Bond, who is actually the father of saturation diving, and has fought a long, tough, uphill battle trying to bring to fruition and to some useful purpose his discovery.

I was associated with the Navy's Sea Lab program through Phase 1, 2, and 3. We had two successes. Sea Lab 3 was an abysmal failure.

The reasons for that failure are manifold. Those of us in the operating arm of the Sea Lab 3 program were frequently called a loose federation of warring tribes. There was fractional effort by the people who were involved and there was fractionated control, authority and responsibility.

There were other difficulties we encountered, and I believe through that experience, that the military is not geared to support or conduct an operation of that type.

The decision was made many years ago to create NASA for the manned space program rather than give it to the Air Force. It is in my mind axiomatic that if we are to pursue meaningful goals in the ocean, that that is analogous to giving whatever mission the Navy has in the sea, or in research in the sea, to a separate civilian organization which has not only funding, but the interest and set mission.

The most appalling thing to me was the disparity between technology that is used to support men in space and the technology that is used to support men in the sea. Space technology outwits the hostile environment. The technology we have for the ocean does not outwit, it overpowers with heavy iron. That is the only approach we have now, and it is insufficient.

What are some other reasons for this disparity? We don't have the same kind of glory, we have no Sputnik yet in the ocean, we have no set mission, we have no competition on an international scale, we have no unity on a national scale, and important also is the fact that we lack understanding and appropriation for and of the ocean and the knowledge and the riches that lie therein.

To a certain extent, I believe that fractionated control and authority and responsibility still exists in Government programs involving the ocean.

What is needed? One agency. NOAA, if you like, if it is properly structured, led and funded, could guide a very comprehensive national oceans program. It needs an operating arm to implement the following projects. Man-in-the-Sea is first on my list.

I believe that if we are to understand the moon, we must send men. If we are to understand the sea, we must send men as free agents to the ocean floor. We need a systems approach to the tools, the habitats, and the life support equipment, and it must be designed with the whole complex in mind, not just single items. Compatibility of the whole complex is vital. NASA has been very effective with the systems approach. It is needed in the sea.

There is a great deal of deep ocean research we could do. We need some nuclear powered submarines for ocean research. Ocean bottom surveys are required. We need to map and photograph, sample with cores. We need to construct temperature and salinity profiles throughout the ocean.

We need to have a better understanding of the current structure of the sediment transport before we can say with any surety that it is safe to dispose of some of our waste in the deep ocean. The knowledge we gain through this comprehensive study of all the world's ocean floors should be made available to all nations.

We need a single agency who can approach salvage. There is much of value on the ocean floor, both what we put there and what was there before we were around. These techniques should be centrally managed and should be made available to all nations.

Marine archeology will benefit from the techniques that can be developed only for salvage. Fishing methods used in this country are absolute. You have heard abundant testimony about the sad state of our fishing fleet. Our methods are archaic, they are destructive, and we are, in effect, raping the benefits the sea can provide us because we, No. 1, do not understand how to husband those riches, and No. 2, we really seem not to care.

We need an extensive buoy network which will help us monitor the weather and one day control the weather. The sky lab program will be very effective in this regard.

Food from the sea, both in plant and animal form, is a vital issue with today's exploding population. The potential is there if we only learn to understand it, protect it, and to utilize it wisely.

I have comments on pollution and dumping which are really redundant since Captain Cousteau's testimony. I will eliminate those.

We have, as I am sure you are aware, legal problems in defining boundaries. We cannot even solve our intramural problems among States and the national boundaries. This creates difficulty for those who wish to work in the sea.

The oil and minerals to be found on the ocean floor are badly needed. The energy crisis is well known to you all, and we are going to have to go deeper and deeper in order to supply our energy needs, but we do not know how.

It may interest you to know that it is said by some that most of the riches of the ocean lie on the continental shelves. The continental shelves added together comprise a land area roughly equal in size to the continent of Africa. The continental shelves are only 600 feet away. The continent of Africa is roughly equal in size to the entire lunar surface 240,000 miles away.

I would suggest that if the moon were carpeted with diamonds, at present at least, we could not bring those riches back. The transportation costs are too high. Not so for the continental shelves.

In addition, 600 feet goes into 240,000 miles 2 million times. Simple arithmetic shows you that this rich area is 2 million times closer than the moon.

There is a need to study the proper implementation of nuclear powerplants offshore. This is another answer to our energy crisis. Studies show that in the year 2000 a substantial increase in the amount of our power requirement will be satisfied by nuclear plants. Therefore, it is necessary for us to study proper siting of these powerplants.

The warm water effluent can be not necessarily a pollutant, it can be used to grow food in all forms. But we need to study it.

From the research that is needed in offshore scientific stations, we can put together badly needed offshore airports and other offshore installations that are of value in our metropolitan areas today.

Last but not least, and I am sure thoroughly understood by you all, is the implication better knowledge of the ocean has for our own security.

Now, some of these things I have mentioned are facts and some are but my beliefs. An arm of this agency that I have proposed is needed to study those beliefs and those facts and separate the two, and then tell the people what are the facts. That could be a public affairs office duty.

There may be a need for another arm which will not only tell the people what is important, but relate to them how this basic research can affect their everyday lives, and how it has the potential to enhance the standard of living for people all around the world.

I think NASA may have dropped the ball in this regard. We had a lot of glory and we had competition, but it was not made sufficiently apparent to the people of this country that the end of the space race is not to be found on the moon. There is no end. When a number of people felt we crossed the finish line by getting to the moon first, the popularity declined, and that, in my view, is tragic.

When those of us who have seen the building of our capability to go to the moon and back safely, look back 15 years and try to think "would that have been a rational speculation 15 years ago?" We say, "Of course not. We did the impossible." Those of us who were a part of that impossible accomplishment came away with blind faith, but a sure faith, that basic research is an absolute essential to our survival.

A brief look at the history of scientific inquiry will show that the gap in time between the discovery and practical utilization of that discovery is getting shorter and shorter and shorter. I believe it took 400 years to first use the vacuum productively after it was discovered. The time got shorter with the discovery of radiation, then the transistor and the laser, and it grows shorter and shorter.

We do not have this pad in time to leave the research to others. We must do it ourselves.

I do believe, as the good Captain Cousteau has said, that our survival depends on the ocean and our knowledge of the ocean. President Kennedy, in words similar, said that indeed our survival may well depend on the ocean, but in my judgment, the suspicion that the survival of life on this planet depends on proper care and feeding of the ocean and upon intelligent utilization and protection of ocean resources, is no longer merely a suspicion, but a fact.

Senator HOLLINGS. That is very outstanding. Mr. Carpenter, since you have been in space and you know the challenges, how would you get us into the ocean? What one single thing would you recommend?

Being very familiar, in other words, with the NASA program, do you think or suggest that we adopt a NASA approach?

Mr. CARPENTER. I do indeed, but you know man can accomplish anything he can imagine if he is given enough time and money.

Now, we have the time if you can give us the money.

Senator HOLLINGS. Well, what about pollution? I think it is significant that we have heard from three expert divers. You eliminated it from your comments because it had been covered very, very dramatically by Captain Cousteau.

What about pollution in your experience?

Mr. CARPENTER. I haven't authoritative experience in that as a diver. I watch with despair what is happening to life along the shore and the potential demise of the pelican, and other life forms. DDT pollution has implications that we have not begun to feel.

I can really add nothing more to what Captain Cousteau has said, other than my wholehearted support.

Senator HOLLINGS. Senator Stevens?

Senator STEVENS. You mentioned the systems approach, Mr. Carpenter. Do you think we need a commitment to a goal, such as a com-

mitment to put a man on the moon, in order to have this systems approach work in regard to the ocean?

Mr. CARPENTER. No, sir. I believe a systems approach is required with respect to the machinery to get those men to the ocean floor—where that is concerned.

I do not know how to take a systems approach to solving the problem of unifying the people behind this worthwhile work. I would be more than happy to be a part of that systems approach. It must involve education of people, and people who will pay for it, but in my judgment, the returns on the investment that needs to be made in the ocean will return tenfold very shortly.

Senator STEVENS. Of course, our major concern is pollution. I share your feeling about it. We just got back, as the Chairman mentioned, from a trip to Alaska and Seattle, and found that mercury entering the food chain of some of our fisheries has reached a level that the Federal Food and Drug people think is at least marginal and in some instances excessive, and I wonder if we do not need to define some of these commitments in regard to the ocean the way we did with regard to the space program.

Everything was oriented toward the ultimate of putting that man on the moon. That was at least a first goal, it was an identifiable goal. It seems to me we have to have an identifiable goal in this program, too.

Mr. CARPENTER. Yes, and there are so many, how do you pick the most glorious? Maybe populating the floor of the Pacific at 5,000 feet for 6 months with a team of 10 men. This can be done, and I think we would all be staggered by the value and the amount of meaningful scientific information that would be brought back.

Senator STEVENS. I think you are right. Thank you.

Senator HOLLINGS. Mr. Shipley?

Mr. SHIPLEY. No questions, Senator. I would just like to say this, Mr. Carpenter, that your thoughts with regards to how NASA may have failed in setting up their program as far as the time and money involved, there is no question that the majority of the people in the world felt that the final goal was putting man on the moon.

In your testimony I suspect that you are attempting to reaffirm what most of them believe, that as we go into the ocean that we should not set any particular objectives, but tackle the problem as a series of whole problems and to take our time so that we will not make the same mistakes that I frankly feel we have made in our space program.

Mr. CARPENTER. Yes, I think that is one answer. I think NASA tried very hard to do the job, but may have failed in making the taxpayer understand how does this moon program benefit his everyday life. We will continue to reap benefits from what we have learned in getting to the moon for hundreds of years. We will get spin-offs. But the people who say "of what value are those moon rocks to me," miss the issue.

It is not what we bring back in terms of rocks. It is what we will benefit, not from getting there and back, but from learning how to get there and back.

Mr. SHIPLEY. I agree with you very much. We have to be cautious, I think, how we set this up or otherwise we are going to defeat our purpose. That is all.

Senator HOLLINGS. Mr. Dingell?

Mr. DINGELL. Thank you, Senator.

Mr. Carpenter, I always become apprehensive when someone talks about setting up one agency to do one thing. I have had, some particularly, bad experiences with NOAA, with NASA, with AEC, and almost every other single mission agency, because they generally tend to get their promotion hat mixed with their control hat, and usually when they have the two hats to choose from, they will choose the promotion hat.

We see it, for example, in the CAB, the ICC, and the FPC. They are busy promoting but not busy controlling. I was very much comforted when you got around to the question of the control of pollution and the protection of the environment and consideration of the environmental concerns.

I wonder if you would like to address yourself to the mission and responsibilities of the agencies that you discussed and how you would see to it that it would consider not only the professional aspects and the research aspects, but what would be its responsibilities with regard to protection of environmental values, prevention of pollution and matters of that sort?

Mr. CARPENTER. I see. First, Mr. Dingell, let me say that I realize what you say is true about the difficulties that you encounter where one agency has total control. I have been personally much more plagued by fractionated effort and no central authority.

Clearly there must be a compromise between the two extremes. And how you would arrive at that compromise, I leave that up to the legislators. That is not my forte.

I believe that Captain Cousteau's idea of involving the 17 nations as it touched on Sky Lab is an extremely fine idea, but that is on the international scene.

On the national scene, I think the organization should be structured as NASA is structured, but with controls that you can legislate into the formation or the other structure of the organization that will take care of the problems that you have encountered in the past.

Mr. DINGELL. I have not been very successful in achieving these kinds of programs with any of the agencies we are discussing. We are finally beginning to get them in line, but it has been an arduous and long fight.

Thank you very much.

Senator HOLLINGS. Mr. Carpenter, you made a tremendous contribution to us today, and we appreciate the special effort that you made in joining us to testify.

Thank you very much.

Mr. CARPENTER. Thank you, sir.

Senator HOLLINGS. We will now hear from Mr. Christian Herter who is the Special Assistant to the Secretary of State for Environmental Affairs.

As we all know, in 1972, the United Nations Conference on Human Environment will be held in June in Stockholm. Mr. Herter is preparing the United States for its participation.

While we have had deep sea divers, Mr. Herter here has been in the deep sea legally and internationally for us, and has got the best knowledge on this score. We have many ambassadors who reported in earlier to join in this conference. We only wish we had time that they could ask questions.

But with that cold word, we welcome you here.

**STATEMENT OF CHRISTIAN A. HERTER, JR., SPECIAL ASSISTANT  
TO THE SECRETARY OF STATE FOR ENVIRONMENTAL AFFAIRS**

Mr. HERTER. Thank you very much, Mr. Chairman. I am delighted to be here and included among such a distinguished group of witnesses.

Unfortunately, I have no formal statement, but if the committee would like me to submit one at a later time, I would be delighted to do so.

My understanding is that you would like to hear from me on the preparations for the Stockholm Conference, particularly as they deal with the subject of ocean pollution.

You may recall, Mr. Chairman, that at the very beginning of the preparations for Stockholm, the Secretary General decided that the only way we could possibly get through any kind of an agenda at Stockholm, there being at that projected meeting some 130 countries—I can't tell you the number of items that have been suggested for discussion at Stockholm—that the action plan of the Conference should be divided into really three levels. The first is what you might call Level 1, an intellectual overlay which is now being prepared with the help of a great many experts throughout the world, which in a sense is a state-of-the-world environment, not unlike the national reports to the Council on Environmental Quality. This will be available to all countries well in advance of Stockholm.

Secondly, the so-called Level 2 action—there is a relevance to this which I will come to immediately in terms of ocean pollution—for those actions that would not be taken at Stockholm but preliminary work would be undertaken and Stockholm might call on a convention, an international agreement, a specialized agency or some other body of the U.N. to take the subsidiary action but Stockholm wouldn't take it. I think most of the proposals for action that have come before the preparatory committees are of this nature.

The third level, Level 3, is the level of action proposals that could actually be accomplished at Stockholm or in advance of Stockholm with the final signing, the final action taking place at the Conference itself.

Now, during the course of the rather endless debates that have taken place in preparation for Stockholm, the first two preparatory committee meetings, and there have now been three, emphasized and focused on what kinds of areas did the world think were important from the point of view of action in Stockholm, and I have attended all these meetings, and by far the greatest unanimity has come out on the subject of protection of the marine environment. Almost every country has mentioned this as what they would consider their number one priority.

As a result, at Prep Comm 2, it was decided that certainly the marine environment should constitute one of the subjects on which hopefully action could be taken in Stockholm, and five international working groups were set up at that particular Prep Comm for the purposes of pursuing particular areas in which it was hoped action could be undertaken.

One was marine pollution; one was monitoring, all forms of monitoring; one was on the declaration, and there are many problems on that, this is a declaration of principles; one on soils, and one on con-

servation. I think it was generally felt these were the five areas in which the preliminary work could be done in advance of Stockholm so that we could take action at Stockholm.

The international working group on marine pollution had its first meeting in London early in June. Some 33 nations were represented. There was an agenda but no one had time to really think it through very completely. The meeting focused in two areas. One, a draft convention on ocean dumping submitted by the United States, and the second was a discussion in some detail of regional arrangements, that is, the North Sea, the Mediterranean, the Black Sea, whatever it might be, regional arrangements for dealing with essentially marine pollution.

Now, as I say, the United States did submit a draft convention on ocean dumping, modeled for the most part along the lines of the domestic legislation that has been submitted by the executive branch and the legislation Congressman Dingell referred to earlier. It was really the subject of the first international working group meeting. It was at least a piece of paper on which people could focus. Countries were asked in the ensuing months to make comments on this draft from their own national viewpoints. This they did, and the United States then at the third preparatory meeting in September submitted purely for consideration a second draft of this ocean dumping convention which draft will be fully discussed at the second meeting of the international working group on marine pollution which, Mr. Chairman, is taking place in Montreal—no, in Ottawa, forgive me—between the 8th and 12th of November.

By and large, the reception of the draft ocean dumping convention that we tabled has been very good, although as time has gone along, people are seeing problems in it. I suppose this is inevitable. Essentially what this does, it calls on nations by agreement to set up a permit system like the domestic legislation. This isn't suppose to answer all the questions of ocean pollution by any manner of means, but it begins to deal with a small facet of it, that is, transportation of wastes, be they toxic or otherwise, from land to the sea and the dumping of them.

It was not felt in London that at this point it was possible to deal with what you might call coastal and estuarine pollution because there are enormously complicated problems involving jurisdictional boundaries and all sorts of things, and as you are fully aware, the so-called law of the sea conference is designed to deal with these problems of territorial jurisdiction. The problem is a very complicated one anyway. When you have an outfall that extends well beyond your own territorial boundaries, whose responsibility does it become then?

It was felt if we can get anything done at Stockholm at all, let's keep it fairly simple, it may not be the world's most meaningful thing, but at least it is a start. It is for this reason that we did draft, based on the domestic legislation, this particular convention. As I say, Ottawa in November will be the second "Look-See" at this convention.

I might just read very briefly to you the three agenda items that will be on this international working group meeting in Ottawa:

"General guidelines and principles for the preservation of the marine environment."

This is something that a number of countries, but particularly Canada, have been extremely concerned about. They have already

tabled, as a matter of fact, and sent around to countries a draft of what they would consider general principles or general guidelines. We thoroughly favor these provided they are at this point guidelines, because again the minute you get into principles and the responsibilities of States, you are getting into what is essentially the jurisdiction of the law of the sea conference.

"Secondly, the constituent elements of a global plan, global approaches at the regional level," essentially a technical subject, where do the pollutants start, what are their concentrations, et cetera, on which there is a good deal of scientific knowledge at the present time.

The third item on the agenda, we hope the one that will be focused on, will be the draft convention on ocean dumping. I think by and large the Canadians, and I don't think I misspeak them at all, feel it is more important to establish general principles first. We feel it is very important to have both. If we can get agreement on general principles, so much the better, but these tend to be very difficult areas in which to get multicountry agreement, international agreement. We are hoping and still are confident that by the time of Stockholm we will have all the elements of an ocean dumping convention fully agreed to so that Stockholm will constitute the official act of signing, and the delegations there will have plenipotentiary powers to sign such a convention which then would be sent to countries for ratification.

I think with this brief summary, Mr. Chairman, I will end my formal testimony. I am sure you are going to ask me what are the real expectations on getting a convention signed, and I think I would say they are still pretty good.

Senator HOLLINGS. That is very encouraging, Mr. Herter. I well recognized in the initial part of your statement that all the countries would give number one priority to the marine environment, and then what would they do about it, and this is very encouraging to have your judgment that they would be prepared to sign a convention at that meeting and that just wouldn't be a conference in Stockholm next June merely to discuss it further. You think there will be a meaningful convention entered into on next June—but how many nations would you think?

Mr. HERTER. Well, Mr. Chairman, I am going to have to hedge my statement by saying this is certainly our hope and we have every expectation that in fact a fairly limited convention of that type I described on ocean dumping will in fact be signed. Undoubtedly there is going to have to be another meeting or two of the international working group on marine pollution to work out the details, but thus far it is our feeling that at least a significant number of coastal nations will in fact sign. Not all the world will sign, not all the world will agree, but if we can get signatures enough to establish a convention, a convention then can be open to signature by other countries.

We are still feeling optimistic with this.

Senator HOLLINGS. The idea was extended earlier that perhaps what we ought to do is to try to get at least the 14 to 18 more polluting nations—there are about 14 to 18 nations that comprise 83 percent of the pollution—that we ought to try to get them together.

In accordance, then, with what you are saying, you don't think that an attempt of that kind would be divisive or hurt in any fashion what is being done at the U.N., do you?

Mr. HERTER. Sir, I think as a practical matter if you take an international working group composed of 33 nations, among them are all the major polluting maritime nations, there should be no problem with an overall U.N. effort.

I might say, Mr. Chairman, there is one thing I forgot to mention which is very important in this whole process: that is the establishment of Senator Baker's advisory committee to the Secretary of State. It is one way we have, if you like, of getting out to the public. There are representatives on this committee [he can speak to it, I am sure], from various sectors of the country concerned with the environment, conservation groups, industries, the universities, special groups such as the League of Women Voters, et cetera, who are very vocal and very concerned. Senator Baker did conduct a public hearing in Miami on the first draft of our convention on ocean dumping in which a number of expert witnesses were invited and on which there was a great deal of comment, and very interesting comment, most of which I would say went to the fact that the convention didn't go far enough.

Of course, it doesn't go far enough. We are fully aware of this. Our great worry is that if it goes too far, some countries will not be willing to accept it at this point.

Senator HOLLINGS. Senator Stevens.

Senator STEVENS. I am very happy to see my old friend here today and to have this very optimistic report.

Mr. HERTER. Senator, I hope I can justify the optimism.

At the third Prep Comm you could begin to see reservations on an ocean dumping convention building in certain countries, but by and large my feeling is that particularly the major polluting nations are very anxious—including the Russians—very anxious to commence with an international convention, and there is no question that in this whole problem, ocean dumping is a small part, and it will, of course, be extended. In 1973 you have a convention of the international maritime consultants organization which deals with shipping and will have on its agenda a resolution passed by NATO with respect to oil pollution of the sea. In addition to tanker standards and navigation and that kind of thing.

In the same year there is supposed to take place the law of the sea conference. The big problem is what part of the whole problem should Stockholm adopt, and Stockholm at least thus far is focusing on pollution from the land.

Senator STEVENS. Thank you.

Senator HOLLINGS. If nothing else, the Stockholm Conference will commence the education process that Captain Cousteau testified to.

Senator Baker.

Senator BAKER. Mr. Chairman, thank you very much.

It is a pleasure for me, after having once served on this distinguished subcommittee, to return now as a guest and as a member of the full committee.

I just want to commend Secretary Herter for an outstanding job as Assistant Secretary for Environmental Affairs. You have done a very

difficult job very well indeed, and I am proud of the appearance that you have given on behalf of the United States in this field to the other countries involved in the preparation for Stockholm.

I am very interested to see the second draft of the ocean dumping treaty that the United States will table at Ottawa. As you know and as you mentioned, our public hearings created a good bit of energy, and one of our advisory committee members I understand will be at Ottawa, Dr. McDonald.

I would say, Mr. Chairman, that I have no questions except to use this opportunity to say that preparation of the American position for Stockholm is in very capable hands and that Secretary Herter has conducted himself in a very capable way.

Thank you very much.

Senator HOLLINGS. When that second draft on the ocean convention is finalized, will you furnish our committee with it?

Mr. HERTER. Absolutely, sir. As a matter of fact, we have it now. We would be delighted to furnish you a copy of it. I am surprised it is not here.

Senator HOLLINGS. We appreciate very much your appearing this morning.

Thank you very much.

The committee will be in recess until its next meeting on November 8.

(Whereupon, at 1 p.m., the subcommittee was recessed, to reconvene on Monday, November 8, 1971.)

# INTERNATIONAL CONFERENCE ON OCEAN POLLUTION

MONDAY, NOVEMBER 8, 1971

U.S. SENATE,  
COMMITTEE ON COMMERCE,  
SUBCOMMITTEE ON OCEANS AND ATMOSPHERE,  
*Washington, D.C.*

The subcommittee met, at 10 a.m., in room 5110, New Senate Office Building, Hon. Ernest F. Hollings, (chairman of the subcommittee) presiding.

Present: Senators Magnuson (chairman of the committee), Pastore, Hollings, Cook, Hatfield, and Stevens.

Also present: Representatives Alton Lennon and John D. Dingell.

## OPENING STATEMENT BY THE CHAIRMAN

Senator HOLLINGS. Ladies and gentlemen, the committee will come to order.

I want to welcome our distinguished chairman, Senator Magnuson, and the other members of the subcommittee, Senator Pastore, Senator Hatfield, and Senator Cook. Plus I think we will have momentarily some visiting members from the House, the chairman of the House Subcommittee on Oceanography, Mr. Lennon, and Mr. John Dingell, chairman of the Subcommittee on Fisheries and Wildlife Conservation.

We convene today the second session of the International Conference on Ocean Pollution. As we meet, the destruction of the oceans continues. Not only does it continue, it accelerates.

We convene today the second session of the International Conference on Ocean Pollution. As we meet, the destruction of the oceans continues. Not only does it continue—it accelerates.

During the first session of the conference—last month—Captain Jacques Cousteau reported that in the past 20 years alone we have inflicted 30 to 50 percent damage to the life of the seas. And when I asked him what the result will be if we continue our present ways, he replied—"I think if nothing was done today, maybe 30, 40, or 50 years would be the end of everything." Other experts concur. They know full well that the Mediterranean has a death sentence hanging over it. That the Atlantic, the Pacific, the Black Sea, the Red Sea, and the Baltic are all in danger of destruction. It takes no expert knowledge to know that if the sea goes—man goes, too. Those who would carelessly sentence the oceans to death can offer no reprieve to man. Nature plays no favorites.

Long ago, man set out to harness the forces of nature. Within a span of two centuries, he gathered unto himself infinitely more power than all his ancestors put together. Man fought nature—and in many respects he conquered. But now we know that if we are to survive—if the planet is to maintain the delicate balances necessary to sustain life—we must look anew at nature. Not as an enemy to be suppressed—but as an ultimate benefactor. Not as a garbage dump for man's wastes—but as our only hope of clean air, pure water, and healthy life.

The summons of today is to join with nature. To protect it. Because in protecting it, we save ourselves. It is as simple as that.

The challenge of the oceans is, in the final analysis, the challenge of human survival.

But the challenge has added dimensions. The seven seas contain enormous resources for the betterment of our lives. They harbor the promise of food. Of jobs. Mineral and petroleum resources. Entertainment and recreation. They offer to mankind untold new dimensions of life and opportunity—compared to which the results of space exploration pale. Scott Carpenter told this conference that if the moon was carpeted with diamonds, its promise could not match the potential of the continental shelves. And yet the exploitation and pollution of those same continental shelves is turning cornucopia into a graveyard.

If the United States were to suddenly come forward with a well-planned and lavishly financed program for national action to save the oceans, the oceans would nevertheless perish—maybe a few months later. We are faced not with a national problem, but an international one. Unless the nations concerned combine to put an end to ocean abuse, the abuse will write *finis* to us all.

This Second International Conference on Ocean Pollution is dedicated to putting people on the alert. Everyone talks a lot about ecology—and, yes—we even join cleanup brigades once every year or so to pick up empty beer cans off the highway shoulder. But we lack a sense of environment priorities. Brigade-size attacks on the flank of the problem might help some, but we need much more a full-scale assault on the heart of the problem. A sound oceans program will provide just that.

Today we have with us three speakers who bring with them a wealth of experience and information.

Dr. Thor Heyerdahl startled the world by demonstrating that the early natives of South America could have crossed the Pacific on balsa rafts. His famed trip aboard *Kon-Tiki* shattered some fondly held theories on the migrations of peoples into the islands of the southwest Pacific. His more recent expeditions on *Ra* and *Ra II* showed that the early Egyptians might have crossed the Atlantic to the Americas—and done it in papyrus boats. Because of Dr. Heyerdahl's work, scholars have had to reshape some of their earlier thinking, just as we must reshape our thinking about our use of the oceans.

Along with our distinguished majority leader, Senator Mansfield, we had the pleasure of visiting in Oslo, and one of the highlights there was to see the *Kon-Tiki* itself.

Dr. Heyerdahl has finished his most recent edition of his expeditions, and we want him this morning to sum up that book.

One of the foremost environmentalists in the world, Dr. Barry Commoner, is also with us today. Dr. Commoner is in the forefront

arguing that we must reshape our economic life if we are to support life itself. Salvaging the oceans portends a massive restructuring of productive technology and economic activity in the advanced industrial nations, and a reshaping of development goals in the less technologically advanced countries. Dr. Commoner will help us focus on environmental and economic issues in the fight against environmental pollution as he has recently done in his excellent book, *The Closing Circle*.

Our final speaker is a communicator and he is an author, too: Yours Truly in 1960, and *Rings Around Tomorrow* in 1970, but we know him best as, the host of television's *Today* show. Hugh Downs is at home on the seas, as a sailor and diver, as most of us are on land. And he shares a deeply felt commitment to act to reverse the destructive trends of contemporary society. He has helped to educate the public through his television interviews. Today we reverse roles and welcome him as a speaker. He brings a special insight into the public's willingness to assume the cost of environmental remedial steps, the bold leadership that government must provide, and the role of his own profession in helping to bring such remedies about.

Unless there are any comments, Mr. Chairman, we will start in with Dr. Heyerdahl.

The CHAIRMAN. Well, Mr. Chairman, I appreciate the opportunity to be here today. I hope the panel will understand and excuse about three of us in a few moments, because we have a very important bill out of this committee on the floor of the Senate, the warranty and guaranty bill, which is going to be worked on today.

I merely want to say that I appreciate being here and I appreciate the leadership of the Senator from South Carolina, who has taken hold of our Subcommittee on Oceans and Atmosphere and all of the problems involved.

This committee, I want to tell the panel, has long been interested in this matter. We passed some of the first oceanographic bills, including the establishing of the famous Stratton Commission.

The Senator from Rhode Island and I gradually discovered that American technology was such that we are ending up now knowing more about the backside of the moon than we do about three quarters of the earth's surface. We would like to level that off a little bit. We would like to level it off with Government support, which we have been fairly successful in moving upward in the past 8 or 9 years. It was practically nothing to begin with.

We found oceanography in the realms of some 26 departments in this Government. And we would like to consolidate that and do a job on it.

So we deeply appreciate all of you being here. We are moving forward, but it is only with the dedication of members of this committee and people like yourself that we can put the whole field of oceanography, which includes ocean pollution, in perspective. I am particularly interested in the fish problem. Seafood is going to have to be a big source of our protein supply in the future.

We have to watch it and all of the other threatened species of marine life. So we are deeply appreciative of all of the help you have given us.

Now on the lighter side, I am glad that my fellow Norwegian is here, and if he can prove that some other people showed up in America long before a couple of other people, you might stop a friendly rivalry that goes on between the Senator from Rhode Island and myself around October.

Senator PASTORE. I still vote for Columbus.

The CHAIRMAN. Yes. Maybe we will both have to have just a big day for everyone who has done a job on the oceans. So if you will excuse me, to get back to the floor on a very important bill, Mr. Chairman, I deeply appreciate your hearings and the type of people that have been interested in this matter. And the hope is, without any criticism of the space program at all, that we can put the priorities where they belong, because three quarters of the earth's surface is our ocean.

As the Chairman pointed out it is our future.

Thank you very much.

Senator HOLLINGS. Thank you very much, Senator Magnuson.

It may be pointed out that when we sought Dr. Heyerdahl, we found him in Italy.

Senator Pastore?

Senator PASTORE. I haven't much to add, but I think while this may be an aside to our discussions today, I think it is what we are trying to get at. I visited a base in Sicily only a month or so ago and they fed us fish for lunch. I inquired if this fish came out of the Mediterranean, and they said, "No, this is imported, we don't eat fish out of the Mediterranean, because of hepatitis."

Now if we are getting down to that stage of what is happening to the water, and what is going to happen to our food, I think we are fast reaching a very perilous state in human society. And I think something needs to be done, and now is the time to do it. I am so happy to be at these hearings, and to have this distinguished company before us.

Senator HOLLINGS. Thank you, sir.

Senator Cook?

Senator COOK. I really want to hear the witnesses, Mr. Chairman.

Senator HOLLINGS. Senator Hatfield?

Senator HATFIELD. I have nothing.

Senator HOLLINGS. Good.

We have just reported out the ocean pollution bill and that is why we are running a little late, and we want to welcome the distinguished chairman, Mr. Lennon, to the committee's hearings.

You have any comments you want to make at this time?

Mr. LENNON. I think I would be listening today rather than talking.

Senator HOLLINGS. Good.

Mr. Heyerdahl, you may proceed.

(The biographical sketch follows:)

#### BIOGRAPHICAL SKETCH OF THOR HEYERDAHL

*Born October 6, 1914 in Larvik, Norway, the only child of Thor and Alison Heyerdahl. His mother was head of the local city museum and she interested Thor in zoology and anthropology. His father was a bank president and brewer.*

*Attended the University of Oslo, specializing in zoology and anthropology. His university department sponsored his first expedition to Polynesia in 1937-38.*

*Thor Heyerdahl and his wife, Liv, lived in Tahiti like original polynesians. They were adopted by the supreme Polynesian chief of Tahiti, Terileroo, in*

1937. While there, Heyerdahl did research on the transoceanic origins of the local island life. He began to doubt all past theories of human and animal migrations set down by noted scientists.

He left Polynesia in 1938 to begin extensive research in libraries and museums in the United States, Europe and Canada, with the objective of testing the many contradictory theories on the origins of Polynesian race and culture.

Heyerdahl published in 1941 his theory that Polynesia had been reached by two successive waves of immigrants from Peru and British Columbia. Attested that the peoples had reached Easter Island and other areas of Polynesia by balsu rafts, carried westward by the tradewinds and the Humboldt Current. Interrupted by the Nazi invasion of Norway, Heyerdahl temporarily abandoned his research and volunteered for the Free Norwegian Forces. Involved in the Free Norwegian Forces until 1945.

Thor resumed his research in 1945 but was met with great resistance by those who believed that a balsu raft would absorb water and sink. Accordingly, the theory that Peruvians reached Polynesia was held untenable for practical purposes.

Heyerdahl, confident of his theory, built a balsu raft, named it *Kon-Tiki* in honor of a legendary pre-Inca sun-king, and left Callao, Peru in 1947. 101 days later—crossing 4300 miles—Heyerdahl and his crew landed safely on the Raroia atoll. His theory that Peruvians migrated to Polynesia on balsu rafts was validated.

In 1952 Heyerdahl, with financial means secured from books and film on *Kon-Tiki*, organized and led the *Norwegian Archaeological Expedition to the Galapagos Islands*, waterless and uninhabited until discovered by the Europeans. Proof of early pre-Inca products on the island established South American archaeology far into the open Pacific.

In 1955 Heyerdahl led another expedition to *Easter Island* under the auspices of Olav of Norway. Sub-surface archaeology had never been attempted on Easter Island. It was discovered that the island had been occupied 1,000 years earlier than heretofore assumed by scientists. The expedition, which took a year, uncovered the largest man-made structure in Polynesia.

In later years, Heyerdahl became interested in the American-Polynesian reed-boats. Scientists had deemed reed-boats impossible for an ocean voyage as papyrus loses buoyancy in less than two weeks, and, furthermore, deteriorates in sea water. In 1969 he bought 12 tons of papyrus in Ethiopia and had a reed-boat built in Egypt. The Chad Boatbuilders followed the drawings of mural paintings from the ancient Nile Valley as blueprints. The boat was named RA, in honor of the sun-God and the sun itself. It was launched at the old Phoenician boat of Safi on the Atlantic coast of Morocco. The seven crew members represented seven nations. After sailing 2,700 nautical miles, the RA (I) was forced to lower its sail one week short of completion.

Ten months later, Heyerdahl tried again with the RA (II), building the boat ten feet shorter. RA II was successful in its voyage and proved that pre-Columbus vessels could have reached tropic America.

#### *Some awards and honors:*

International Congress of Americanists  
 Pacific Science Congress  
 International Congress of Anthropology and Ethnology  
 New York Academy of Sciences  
 Rotary International  
 Honorary Doctorate, University of Oslo  
 Geographical Societies of Norway, Peru, Brazil, Belgium, Sweden, France  
 Lomonosv Medal, Moscow University  
 Lions International  
 Retzins Medal, Swedish Society for Anthropology and Geography  
 Mungo Park Medal, Royal Scottish Geographical Society  
 L'Oscar Internationale del Mare, Pegli  
 Polena della Bravvura, San Remo

#### *Some books:*

*Kon-Tiki* (translated into 64 languages); Academy Award Oscar for best documentary in 1951; Academy of Motion Pictures Arts and Sciences Award in 1952; Oslo, 148  
*American Indians in the Pacific; The Theory Behind the Kon-Tiki Expedition*, Stockholm, London, Chicago, 1952.

*Aku-Aku: The Secret of Easter Island*, Oslo, 1957, Rand McNally & Co., U.S.  
*Vanished Civilizations*, London, 1963.  
*Sea Routes to Polynesia*, Vienna, London, Chicago, 1967.  
*The Ra Expeditions*, Oslo, 1970; United States 1971.

*Present activities:*

Dr. Heyerdahl is a board member of the Kon-Tiki Museum in Oslo, which he founded with his Kon-Tiki expedition friend, Knut Haugland, director of the Museum. The entire proceeds from the Museum, the most frequented in Norway, go to a fund for students.

Heyerdahl is also a Vice-president in the World Association of World Federalists, participating in various congresses and organizations working for international understanding and cooperation, as well as for protection of nature and international efforts against pollution.

In 1958, Heyerdahl moved his working base from Oslo to a small and nearly abandoned medieval hilltop on the Mediterranean coast of northern Italy. Here he has settled with his Norwegian wife, Yvonne and his three daughters, Anette, Marian and Elisabeth. He has two grown sons, Thor and Bjorn, by his first marriage.

**STATEMENT OF DR. THOR HEYERDAHL**

Dr. HEYERDAHL. Distinguished Senators, ladies and gentlemen: There are times when an observation is made by someone who is looking for something else. This was the case when the present speaker experimented with prehistoric types of watercraft to travel back into man's past, and yet stumbled upon three practical observations which have a bearing upon man's future: (1) The ocean is not endless; (2) There is no such thing as territorial waters for more than days at a time; (3) Pollution caused by man has already reached the farthest section of the world ocean.

It may seem superfluous to state that the ocean is not endless, something the world has known since Columbus crossed the Atlantic in 1492. Yet I dare insist that this fact has not sufficiently penetrated our minds, we all subconsciously act as if the ocean has horizons running into the endless blue sky. When we build our city sewers in pipes far enough into the sea, when we dump poisonous refuse outside territorial borders, we feel we dispose of it forever in a boundless abyss. We have known for centuries that our planet has no edges and that the oceans interlock in a never-ending curve around the world, but perhaps it is this uninterrupted curve that gives us the feeling of endlessness, this feeling that the ocean somehow continues to curve into space. From all continents we keep on sending our refuse into the presumably endless ocean almost with the impression that we send it away into space. Rarely do we stop and think of the fact that the ocean is nothing but a very big lake, landlocked if we go far enough in any direction. Other than being the largest body of water on earth, its main distinction from other lakes is that they usually have an outlet to carry away excessive natural solutions and pollution, whereas the ocean has none. Through a worldwide, nonstop flow, all the excess, waste, and refuse that run from lakes and land assemble in the ocean, and only clean water evaporates back into the atmosphere. There were days not far back when our ancestors would laugh at the idea that man could pollute and kill a lake so big that nobody could see across it. Today Lake Erie is only one of a long series of lakes destroyed by man in the most different parts of the world. Place 10 Lake Eries end to end and they span the ocean from Africa to America. True, the ocean is

deeper than any lake, but we all know that due to photosynthesis the bulk of life is restricted to the thin upper layer, and we also know that an estimated 90 percent of all marine life happens to be on the continental shelves which represent only 10 percent of the total ocean area. Add to this that if half a dozen towns send their refuse into Lake Erie, all the cities, all the farmlands, all the rivers and ships of the world channel their refuse into the ocean, directly or in a round-about way. No wonder, then, that a time has come when even the world ocean has begun to become visibly polluted.

This discovery, which was first forced upon me while drifting at surface level in the mid-Atlantic in 1969, helped to open my own eyes to the fact that the ocean has its limits, and the closer one gets to know it the more easily this can be perceived. When we rush across it with engine-driven craft we feel that it is thanks to the modern traveling speed that the continents seem to be not so immensely far apart. But when you place yourself on a primitive raft and find that, entirely without engine or modern means of propulsion, you drift across the largest oceans in a matter of weeks, then you realize that you made it, not because of modern technique but quite simply because the ocean is not at all endless.

With a speed slightly faster than that of average surface pollution, I crossed the Pacific from South America to Polynesia on nine balsa logs in 1947, and, on bundles of reeds, from Africa to the Caribbean Islands almost twice within a year in 1969-70. Each of these oversea voyages on an aboriginal type of watercraft was intended as an eye opener for fellow anthropologists who, like the average layman, have retained the universal concept of the ocean as an endless waste, unsurmountable by pre-Columbian craft because of its boundless dimensions. This concept is wrong, and we run the risk of harming ourselves dearly unless we abandon this medieval concept of the endless sea and accept the fact that the ocean itself is nothing more than a big, salt lake, limited in extent and vulnerable as all the smaller bodies of water.

A second dangerous illusion equally hard-die is the image of territorial water. We draw a line parallel to the coast, 3 miles, 10 miles, or a 100 miles off shore, and declare the inside as territorial water. There is no such thing as territorial water, the ocean is in constant motion, like the air. We can draw a line on the ocean floor and lay claims to the static land on the bottom, but the body of water above it is as independent of the map as is the atmosphere above dry land: wind and currents disregard any national borderlines. Refuse dumped inside Peruvian territorial waters equals refuse dumped around the shores of Polynesia; refuse dumped inside Moroccan territorial waters equals refuse dumped in the Caribbean Sea. Any liquid piped into the port of Safi in Morocco, and any buoyant material dumped outside the local breakwaters just where our papyrus bundle-boat was let adrift, will run along as on a river straight to tropic America where some will wash against the beaches and some will move on up along the East Coast of the United States. Moroccan territorial waters in a matter of weeks or months become American territorial waters, with all the good and evil this may involve. The salt sea is a common human heritage, we can divide the ocean floor between us, but we shall

forever be deemed to share the common water which rotates like soup in a boiling kettle: the spices one nation puts in will be tasted by all the consumers.

Only when we abandon the almost superstitious awe for the immensity of the sea, and the misconception of coastal water as a stagnant body, can we fully understand what is happening when visible pollution is scattered the full length of the North Atlantic surface current which flows perpetually from northwest Africa to tropical America. This entire span of the ocean, from continent to continent, contain among other modern refuse an immeasurable quantity of small drifting oil clots. They were accidentally noticed during the crossing with the papyrus raft-ship Ra I in 1969 and deliberately surveyed and sampled the next year during the crossing with Ra II.

In fact, in organizing our marine experiment with the first papyrus vessel ever to be tested at sea in modern times, our expedition group was initially unprepared for pollution studies. The objectives of the enterprise were to investigate the sea-going abilities and geographical range of the oldest type of watercraft used by man's earliest civilizations in the Mediterranean world as well as in Mexico and Peru, and furthermore to test the effects of multinational cooperation in cramped quarters and under stress. We were seven men from seven nations on Ra I and eight from eight nations on Ra II. At sea, however, early in the voyage of Ra I, pollution observations were forced upon all the expedition members by its conspicuous presence and undoubtedly also because of our own proximity to the ocean surface with a slow progress through the water.

Departing from the Moroccan port of Safi on the northwest coast of Africa on May 25th, 1969, the seven men on board Ra I became aware of traveling in polluted water for the first time on June 6th, at 24°38' N., and 17°06' W., or about a 100 miles (160 km.) off the coast of Mauritania. The sea was now rolling calmly and we noticed the surface to be densely scattered with brownish to pitch-black lumps of asphalt-like material as big as gravel and floating at close intervals on and just below the surface. The clots were drifting with the surface current in our direction, but benefiting more from the tradewinds we moved considerably faster, averaging a speed of about 2 to 2.5 knots.

The local current speed is about 0.5 knots. Knowing that our reed vessel was near the circum-African shipping lane, we climbed the mast and began to scout for ships, being convinced that we had entered the wake of some nearby oil tanker that had just cleaned its tanks. No ship was seen.

On June 8th, having advanced about a 100 miles farther to the southwest, we found ourselves again sailing through similarly polluted water, still without any ship in sight. The following day we sailed into an area of the ocean where the same flotsam included pieces of larger size, some appearing as thick, black flakes of irregular shape up to 5 to 6 inches in diameter. The local ocean water itself gradually turned into an opaque and grayish-green color instead of being transparent and clear blue; it was recorded in the expedition journal as resembling harbor water at the outlet of city sewers.

Although sporadic lumps were noted, no specific entry was made in the expedition log until June 30th, when our position was at  $15^{\circ}45'$  N. and  $35^{\circ}08'$  W., that is virtually in the mid-Atlantic with Africa and America almost at the same distance. Here once more we suddenly entered an area so polluted that we had to be attentive in washing ourselves or dipping our toothbrush into the water, to avoid the seemingly endless quantities of oil clots of sizes ranging from that of a grain of rice to that of a sandwich.

Ra I covered 2,700 nautical miles in 54 days, and on July 15th and 16th, shortly before abandoning the test vessel we found ourselves again in the same general type of polluted water. Our position was now  $13^{\circ}32'$  N. and  $47^{\circ}20'$  W., or some 600 miles east of the island of Barbados and slightly closer to the mainland coast of South America. Many of the clots had an eroded or pitted surface, and small barnacles as well as algae were occasionally seen growing on them.

Some samples were collected and at the end of the voyage delivered with a brief report to the Permanent Norwegian Delegation at the United Nations. Although no deliberate or preconceived observations were made, the voyage with Ra I resulted in the involuntary recording of 6 days' traveling through visibly strongly polluted water in the course of eight weeks of transatlantic sailing. Thus, more than 10 percent of the surface water traversed by Ra I was visibly polluted by a rich flotsam of nonorganic material of rather homogenous appearance and undoubtedly resulting from modern commercial activity.

Our report to the United Nations in 1969 aroused a general interest, not least among scientists and shipping authorities, and prepared for what we might again encounter, we decided to keep a systematic record of daily observations when we embarked on the voyage of Ra II the following year.

Ra II was again launched outside the breakwaters of the same ancient port of Safi in Morocco, this time on May 17, 1970. As the water along the west coast of Africa and in the latitudes where we were to undertake the Atlantic crossing is not at all stagnant, but moves towards America with a speed of 0.5 knots or more, it is clear that we did not voyage through the same surface water this second time. In fact, the surface water observed by us from Ra I had been displaced more than 4,000 miles during the year that had passed between the departures of the two consecutive raft expeditions.

On other words, the water which we traversed along the African coast in May 1969, had long since deposited its flotsam along the Caribbean shores or else carried it into the initial part of the Gulf Stream, by the time we embarked on the second voyage in 1970. Correspondingly, the water seen around us as we abandoned Ra I short of Barbados in July 1969, would this subsequent year be on its return flow with the Gulf Stream back across the North Atlantic, heading for Europe. Nothing could impede this eternal circulation of ocean water, westwards near the equator and eastwards in the far north, caused by the rotation of the earth itself. Thus the pollution we saw during Ra II was wholly independent of anything we observed on Ra I.

During our experiment with Ra II, in addition to the regular entries in the expedition log, a special pollution record was kept by

Madani Ait Ouhanni, who also at reasonable intervals collected samples of the asphalt-like clots which, toward the end of the voyage, were handed to the United Nations' research vessel Calamar for subsequent transfer to the Norwegian U.N. Delegation.

The samples were taken by means of a fine-meshed dip net. It should be noted that in the rippled seas oil clots were difficult to detect unless washed on board or drifting past very close to our papyrus deck. Only when the wave surface was smooth, or the floating objects were of conspicuous size, was it possible to detect and record pollutants passing more than 6 or 8 feet away from the Ra. Thus, the considerable quantities of oil clots and other floating refuse which were found to float close alongside our papyrus bundles reflect the true dimensions of the problem if estimated in a broader geographical scope. It should also be noted that the route followed by Ra II was straighter and somewhat more northerly than that of Ra I which constantly broke the rudders and was forced on a drift voyage down beyond the latitude of the Cap Verde Islands.

On the background of these facts, it is disheartening to report that drifting oil clots were observed 40 out of the 57 days it took Ra II to cross from Safi to Barbados. This means that 72 percent of the traveling time was spent in water where oil clots could be seen.

From May 17, 1970 when we left the port in Morocco (at 32°20' N. and 9°20' W.) until and including June 28 when we had reached 15°54' N. and 45°56' W., we recorded oil pollution on 40 days out of 43. On the 3 days when pelagic oil lumps were not seen, Ouhanni's entries in the pollution record state that the sea was too rough for proper observation. It may thus be safely assumed that the 2,407 nautical miles covered by Ra II during the initial 43 days of its voyage represented an uninterrupted stretch of polluted surface water, the degree of visible pollution varying from slight to very grave. It is slightly encouraging to note, however, that with the exception of some sporadic lumps observed on July 30th, no record of such particles was made during the remaining 700 miles to Barbados. This curious fact should not delude us though, since this was the very area where we noted extreme pollution the previous year. Also, on our arrival in Barbados, the owner of our east coast hotel reported that oil clots were sometimes so common on his beach that it was a problem to keep carpets clean from lumps that had stuck to his clients' feet.

Perhaps the sudden disappearance of oil clots in front of the Caribbean Islands during the 1970 crossing can be ascribed to a temporal irregularity in the local movement of water. The disappearance of the clots coincided with the sudden arrival of feeders from northbound branches of the south equatorial current, which were noticed both in our own displacement and simultaneously indicated by sudden changes in water temperature. Nevertheless, although the seemingly ever-present oil lumps disappeared this time, plastic containers and other imperishable man-made objects were observed sporadically until the last day of our crossing.

The average extent of oil pollution recorded during the voyage of Ra II amounted to lumps of asphalt-like material the size of finger-

tips or smaller, scattered far apart in otherwise clean water. There would be days when only a very few such lumps could be seen from sunrise to sunset, whereas in exceptional cases the water was so polluted that a bucket could not be filled without some floating clots being caught at the same time.

The first very seriously polluted water was entered by Ra II 4 days after departure, on May 21st, at 29°26' N. and 11°40' W., about 100 nautical miles off the African coast before we entered the passage between the Canary Islands and Morocco. From early that morning until the evening of the following day, Ra II was drifting very slowly through calm water that was thickly polluted by clusters of solidified oil lumps commonly of the size of prunes or even potatoes. Many of these lumps were dark brown, mousey, and pitted, more or less covered by marine growth, whereas others were smooth and black, with the appearance of being quite fresh.

For a duration of 2 days, the surface water, containing large quantities of these lumps, was also covered intermittently by a shallow white foam such as develops from soap or synthetic washing powder, while occasionally the ocean's surface was even shining in rainbow colors as from gasoline. The sea was smooth and a vast quantity of dead coelenterates could be seen for considerable distances on both sides of our track. The expedition journal recorded that "the degree of pollution is shocking."

The following week only sporadic lumps were noticed, until on May 29th, at 25°43' N. and 16°23' W., when our records again show that "the pollution is terrible." During the previous night oil lumps, of which the biggest were the size of a large fist, had been washed on board during darkness, to remain as the water filtered through the papyrus like through the fringes of whalebone. Barnacles, marine worms, crustaceans, and sometimes bird feathers, were found attached to the oil lumps.

The high degree of pollution was this time witnessed for 3 consecutive days, when swimming inevitably meant colliding with the sticky clots. On May 31st, at 25°00' N. and 17°07' W., the expedition journal has the following entry: "An incredible quantity of shell-covered asphalt lumps today, big as horse droppings and in clusters everywhere. One plastic bottle and one metal oil can also observed, plus a large cluster of greenish rope, and nylon-like material besides a wooden box and a carton. It is shocking to see how the Atlantic is getting polluted by man." No ships were seen in the vicinity.

The next entry into seriously polluted waters was on June 16th. At 18°26' N. and 34°28' W., again virtually in the mid-Atlantic, the surface of the waves and as far as we could see below contained endless quantities of large and small oil lumps.

Ra II completed its Atlantic crossing on July 12th, 1970, landing on Barbados after covering 3,270 nautical miles in 57 days. Although pelagic oil clots represented the most consistently recurring type of visible pollution during the two Ra voyages, it should be made clear that other debris from man of a rather heterogeneous kind was also common, even where oil was absent. Thus, in 1970, pollution in the form of plastic containers, metal cans, glass bottles, nylon objects,

and other perishable and nonperishable products of man, representing refuse from ships and shores, passed close by the sides of our raft at intervals from the day of departure to the day of landing.

This was in marked contrast to our experience during the voyage of the raft *Kon-Tiki* two decades earlier. A noted aspect of that voyage, which then took place in the Pacific, was that not a single oil clot, in fact not a single sign of man's activities, was seen during the 4,300 mile crossing. From the day we left Callao in Peru until we landed on Raroia atoll in Polynesia 101 days later, we were constantly impressed by the perfect purity of the sea. The first trace of other human beings observed was the wreck of an old sailing vessel thrown upon the reef where we landed. Although, in fact, the contrast refers to two different oceans, the currents rotate between them and the difference between observations in 1947 and 1970 is so marked that it probably has some bearing on the rapidity with which we pollute the sea.

Through the State Department of Norway, a meeting was arranged between representatives from different scientific institutions and the oil industry who were invited to discuss an analytic program for the oil clot samples collected by the *RA II* expedition. The analytic program was designed to determine whether the samples represented crude or refined oil, and also to estimate the origin, whether it could be leakage from drill, scattered oil from a single wrecked super-tanker like *Torrey Canyon*, oil from marine organisms, or mixed discharges from many different vessels. The analytic work was carried out by the Central Institute for Industrial Research in Oslo, and their findings can be summarized as follows:

The results of the infrared spectras show that the samples consist mainly of saturated hydrocarbons or mineral oil. Some samples seem to contain compounds from decomposed crude oil or heavy fuel oil. Vegetable and animal oils are apparently absent. According to the results of a gas chromatographic analysis the saturated hydrocarbons were normal paraffins (n-paraffins) with 14 to 40 carbon atoms in each molecule with maximum around 20 and 30 carbon atoms. Such n-paraffins are generally, but not exclusively, the major fractions in mineral oil from the United States of America and North Africa. The samples showed a wide range in their contents of nickel and vanadium which indicate that they have derived from geographically different sources.

In short, the conclusion was that the countless oil clots drifting about from continent to continent represent crude oil pollutants not from one leakage or one wreck, but from different origins. We are hardly far off then if we suspect the major part of the oil clots to be the scattered refuse from the numerous tankers which daily discard their ballast water at sea before entering port of loading.

It was not an objective of the *Ra* expeditions to draw biological or ecological conclusions from our observations. Our aim is merely to call attention to observations that were virtually forced upon us by our prolonged proximity to the surface of the sea. Yet, one cannot refrain from certain deductions. Clearly, the time has passed when ocean pollution was a mere offense to human aesthetics because the

surf throws oil and scrap up on the holiday-makers beaches. Much has been written about the tendency of oil molecules to expand in thin layers over wide areas of water, thus impeding the photosynthesis needed by the oxygen-producing phyto-plankton. Those of us who sat on the two Ras observing fishes, large and small, nibbling at any floating particle wonder how the almost ever-present oil clots can avoid affecting the metabolism of the marine fauna and flora; not least the filter-feeding fishes and whales which swim with open mouth and, like the reed bundles of Ra, let the water sieve through whereas Plankton and oil clots alike get stuck in gills, whalebones, or intestines. Small fish may get wise to the presence in their own element of unpalatable oil clots, but larger marine species have no way of gapping over plankton without getting in nonorganic material floating alongside as well.

In addition, the oil lumps examined showed that they very frequently provided a foothold for live organisms which ride along as a sort of bait attracting the attention of bypassing fish. I am referring here to the fact that small Cirripedia, or edible barnacles (identified as *Lepas pectinata*) were very commonly sitting in regular clusters on the lumps. Various edible crustaceans were also frequently found clinging to the lumps, notably an isopod (*Idothea metallica*) and a small pelagic crab (*Planes minutus*). Marine worms hid in the pitted surface, and the shell of a tiny dead cuttlefish (*Spirula spirula*) was found in one sample.

In closing, may I be permitted a personal remark? A much more far-reaching study than our improvised sampling will be needed before we can judge the durability and effects of this steadily increasing flotsam of oil and debris. Perhaps bacterial activity and disintegration will finally sink or efface the oil from the ocean's surface, but certainly not before a large percentage is washed up against the continental and island shores.

Having first personally witnessed the almost uninterrupted host of clots rotating about in the mid-ocean, I have subsequently visited some shorelines of the three continents bordering on the land-locked Mediterranean Sea and found a belt ranging in color from gray to black along the waterline of cliffs exposed to the polluted surf.

In certain areas, like on the otherwise attractive island of Malta, it is as if the entire coastline to a height of 6 or 8 feet above water level has been smeared by a black impregnation. Where the invisible marine paint brush has been at work there is no sign of life, neither algae nor mollusks, crustaceans or any other marine species naturally at home on such rocks. The coastal cliffs and reefs represent, as we know a major breeding place for pelagic plankton and a necessary stepping-stone in the life cycle of a great many of the species of paramount importance to man.

I stress again, there are few things as illusive as the concept of territorial waters. What others dump at sea will come to your shores, and what you dump at home will travel abroad irrespective of national legislation. We must start at the national level, but we must

quickly move on to international agreements if we shall be able to protect our common ocean for future generations.

(The map follows:)

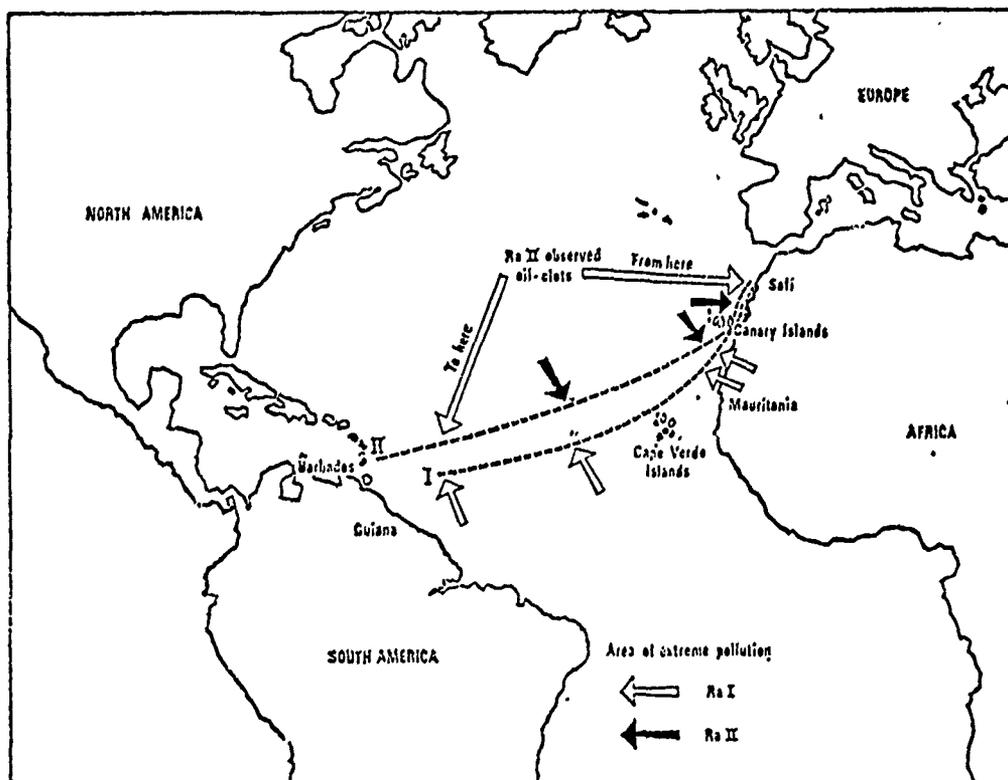


Fig. 1. Sketch-map indicating trans-Atlantic voyages of Ra I in 1969 and of Ra II in 1970. The arrows indicate areas of extreme pollution.

Colla Micheri, Italy  
November 6th 1971

*Thor Heyerdahl*  
Thor Heyerdahl, Ph.D.

Senator HOLLINGS. I thank you very, very much, Dr. Heyerdahl.

The map at the end of your statement will be included and I may observe that you testify like we lawyers would like a witness to testify as to what you have seen with your own eyes and what you have observed at fixed minutes and degrees. You have distinguished between not just the oil clots and pollution, but other pollution. You have really put it in a very dramatic fashion, not really seeking pollution, but you observed 40 days out of 43 days there was nothing but pollution.

I don't know of a more convincing statement about the acceleration of pollution in the seas.

Let me ask you this about oil. I know we produce some two billion gallons, and 67 percent of that is transmitted by vessel, and almost a million tons, not gallons, by accident is dropped into the ocean each year. That does not include waste from the actual drilling or the cleaning out of bilges on the ships.

How long does an oil waste persist within the ocean? I know you are observing the actual surface. I am told, I believe, that below the surface it will last for quite sometime. It might be cleaned-off the

beaches, it might be broken up with large oil clots, but below the surface itself I think it persists for some time.

Do you have any observation about that?

Dr. HEYERDAHL. No, sir, I have no observation on the durability. But we could see, even with our own eyes, that there was quite a difference in time between the dumping of the various samples.

As I mentioned, some were quite fresh, black and shiny, and some were completely pitted and covered by marine growth. But the fact remains certain that even if it does disintegrate within a reasonable amount of time, a large portion will be washed up against the coasts before this happens. And I made a purpose of visiting some of the shorelines of the Mediterranean where this can be so easily observed, the distances are smaller, and I suppose the percentage of oil deliberately dumped is at a maximum. There is more than 100,000 tons of oil dumped per year in the Mediterranean, intentionally, and this is more than the Torrey Canyon lost in that famous accident in the British Channel.

Now this oil is washed up on the cliffs and as I mentioned where this takes place life is killed. There are two possibilities for this. One is that oil itself covering the cliff denies the local marine life the necessities of thriving. Another danger which was mentioned at the conference on the ocean held at Malta this year, where I was present, was that the floating oil has a tendency to absorb the chlorinated hydrocarbons. That is, they will absorb them to an extent that the concentration in some of the oil might be even higher than what it is at the time we spray it against insects.

I am not a chemist, but if this statement, which was made by chemists, if this is correct, we can well understand that this material which is invented to kill life we do not desire ashore, if it gets washed up on life on the coast, it will have the very same effect.

Personally, I was quite shocked at what I saw on the coastline. I was accompanied by my son who is a professional marine biologist, and he was so depressed at what he saw that he couldn't find words. He said precisely what we heard repeated from the last meeting here by Dr. Cousteau that there is a great danger of the oil absorbing other venomous substances that will kill life in the ocean within our generation.

Senator COOK. Can I interrupt a second, Doctor?

Along the line which the Chairman was pursuing, did the substances you found on your voyage, constitute refined substances, as opposed to crude oil? This sounds like it is heavy bunker fuel. As a matter of fact, some of those fuels are so heavy they even have to be heated before they can be forced into a furnace to burn. This was the kind of substance you were finding that was forming large globules, which were so heavy they could pick up other particles, were they not?

Dr. HEYERDAHL. I should like to read a brief statement of the report from the analysis.

Senator COOK. What I am trying to say is that as opposed to raw crude, what you were finding constituted a manufactured item that was either discharged from vessels, because of totally faulty equipment, or whatever the case might be.

Dr. HEYERDAHL. Yes. I will read the exact wording of the conclusion of the analysis. It says that, without giving details about the different samples, the SI reports states that "The samples are

crude oil pollutants from different sources. Some samples seem to contain components from decomposed crude oil or heavy fuel oil."

Senator HOLLINGS. From your experience in reporting, I think that is very impressive.

Dr. Cousteau suggested perhaps the 14 to 18 most polluting nations should get together. We all welcome the Conference on Human Environment next June in Stockholm. I am convinced this Congress is ready to act. Obviously, though, no action is going to have any effect unless we get together. We can't clean up our shores until we start in Morocco, according to your testimony, or they can't start until we clean up ours.

Would you have any suggestion along that line as to how we might accelerate some type of action?

Dr. HEYERDAHL. Mr. Senator, my feeling is that all we can do at the present state is to prepare the best we can for the United Nations' conference to be held in Stockholm. I do know that all the nations participating are involving the best scientists, the best authorities they have on the topic. But I do feel that there is a great danger that we will end up with a lot of talking without action. So my feeling is that what ought to be done today on the national level is to convince our own Government of the importance of doing something, that we are not talking about aesthetics, that we are talking about human survival. And I think that anything that can be done by any politician or any private citizen to convince his government to this extent that something is being done and not that we are only ending with a lot of useful information and nothing else in Stockholm. This is my feeling.

Senator HOLLINGS. That is exactly the point and the frustration that we have. The inference, of course, is not that the Pacific is clean and the Atlantic is polluted, but rather that there has been an acceleration of pollution in the Pacific as well as the Atlantic, wouldn't you say?

Dr. HEYERDAHL. Yes, certainly, because we do know the waters of the two areas are connected. The currents passing the southern tip of the new world run right into the Atlantic and there is a constant movement in the water of the ocean.

To give you one very clear example of this, I may again refer to my young son oceanographer from the University of Oslo. When I was testing the papyrus boat last year, he was leading an expedition into the Greenland current, where he was permitted to catch 20 whales for scientific purposes. They found DDT in the blubber of all of these whales, together with all of the other six known chlorinated hydrocarbons. These whales were swimming in the Arctic currents coming straight down from the North Pole. In other words, in the water they live on the east coast of Greenland, they breed and live there, they have never been in the neighborhood of any agricultural land. That shows the way the ocean is rotating, this is why I speak of a boiling kettle.

We cannot distinguish between them. Certainly a land-locked sea like the Mediterranean, like the Caribbean, the Caspian, some of these oceans have much less circulation and are in much greater immediate danger. But when we speak of the great oceans, they communicate.

Senator HOLLINGS. Senator Pastore?

Senator PASTORE. I have to leave, Doctor, but I would like to ask you a question before I go.

Is it your theory—I understand that in New York City they take their garbage out to sea and dump it—is it your theory that much of it comes back?

Dr. HEYERDAHL. This depends on what kind of refuse we are speaking about. I think that it is very important to distinguish between refuse and refuse. The natural cycle of the ocean has for as long as the world has existed, had the ability of rearranging a lot of material. If we speak of the usual organic matter, I would not include it in this discussion, because it will act as food for other organic matter, much of it will be converted and come back in use.

The big danger, the great danger of today is that man through his great skill has invented certain materials that were unknown to nature and nature has no means of disposing of it, no means of making use of it. It is like nuts and bolts running around in a readymade machine, doing damage, and never getting out of the machine. These are the chlorinated hydrocarbons and a lot of other chemicals, plastics, et cetera, nylons, floating about.

Senator PASTORE. But as an expert in oceanic travel by force of current, and current alone, without mechanical propulsion, your theory is that a pollutant dumped from one continent will show up on the shores of another. Is that correct?

Dr. HEYERDAHL. This is correct. And if I understand your question correctly, it is also coming back to your own shore again in due course of time. The water which runs off the American coast, the North American coast on the Atlantic side, the Gulf Stream branches off in the neighborhood of northern Europe. A large portion of it turns down by the coast of Portugal, the Canary Islands and comes straight back to the Caribbean Sea which is again the same as entering in the Gulf Stream again. There is a great circle movement in the North Atlantic, there is another corresponding one in the South Atlantic, there are two corresponding rotations in the Pacific. We are getting it back, what we throw in, if it isn't washed up somewhere else or if it isn't lost by disintegration or otherwise, we have a great chance of getting a good deal of it back again.

Senator PASTORE. Thank you.

Senator HOLLINGS. Senator Stevens?

Senator STEVENS. If I understand you, what you are saying is we should not only be certain that our tankers or vessels don't dump their bilges, but we should also find some way to enforce them all to have incinerators and normal waste disposal, so they don't dump the plastic cans and all of the rest of the things in the oceans that you found.

Do you believe that is the case, too?

Dr. HEYERDAHL. This is correct, sir. But in this case I think that all of the big cities of the world send much more of this matter into the ocean than perhaps the whole fleet of vessels put together. When it comes to the oil, I assume, without knowing what I am speaking about, but I assume that the major portion of it comes from various ships. But when it comes to the normal refuse, I think that the coastlines have the major responsibility. Because we send, no matter where the city is, we send our refuse in one way or another into the ocean.

Senator STEVENS. Senator Hollings and I spent some time in my State looking into the problems of mercury recently. I appreciate your comments about the DDT in the whales, because we found increasing traces of mercury in the fishery resources of the North

Pacific, while we actually don't have that much activity up there that would lead to a man-made mercury deposit or mercury runoff.

I found that comment very interesting.

Senator HOLLINGS. In the halibut, the Norwegian fishing village of Petersburg in Alaska.

Senator STEVENS. I am very grateful to you for your statement. Thank you.

Senator HOLLINGS. Senator Hatfield?

Senator HATFIELD. I have no questions.

Senator HOLLINGS. Chairman Lennon on the House side, do you have any questions?

Mr. LENNON. Thank you, Mr. Chairman.

I do want to thank the doctor for his most interesting and informative and seriously challenging statement. I think you have brought here to the individual members of this committee and those of us who are counterparts in the other body, a documentary statement of what your actual findings are that I wish were required reading of every American and every citizen of every nation.

If that could be done, and hopefully it will be done in time, then we would reach the goal that I think all of us ascribe to. I am very grateful for this opportunity to hear you.

Senator HOLLINGS. Mr. Dingell, the chairman of the House Subcommittee on Fisheries and Wildlife Conservation.

Mr. DINGELL. Thank you, Senator.

I would like to express my appreciation to you and to the committee for the privilege of being here.

Dr. Heyerdahl, I was much impressed with your testimony. I have no questions except to comment that read together with the remarks of Captain Cousteau a while back and in testimony received by the joint hearings conducted by Mr. Lennon and I, indicate that the oceans are in great trouble and something rather strikingly more than has been done so far is urgently required. I think the only thing I can do is to indicate the best efforts of Mr. Lennon and myself and our colleagues on the Senate side will be directed toward doing something about it in the time that it must be done in.

Thank you.

Senator HOLLINGS. Thank you.

One of the impressions we receive from all of the witnesses is the need for immediate action. Dr. Heyerdahl, we could keep you here all morning, but I am committed to try to dispose of this before lunchtime. If you have nothing to add, we thank you very, very much and we will now hear from Dr. Barry Commoner.

#### STATEMENT OF DR. BARRY COMMONER

Dr. COMMONER. Thank you, Senator Hollings. I am very glad to be here because I regard this conference as something which goes well beyond even the grave problem of the ocean. I think that you are holding this conference at a crucial moment in the history of U.S. and world concern with the environment. In a way what happens here and what happens in your considerations of the problems of the ocean has become, I think, a test of our real understanding of the environmental crisis.

I think that we can use this issue as a test also of our sincerity in really dealing with these problems. I share with many of you the feeling of frustration which has, I think, descended upon many people in this country regarding the will of our administration to really face up to the hard facts of environmental survival.

What I would like to do today is to share with you some of the thoughts that I have developed which I think help to explain why the issue of environmental survival has become so enmeshed in delays, evasions, and in, I am afraid to say, political concerns. If you will bear with me, I want to give you my views on that and the evidence which lies behind it. I think that it is clear from what Dr. Heyerdahl has said, following the testimony of other oceanographers, that the oceans of the world are in a serious, grave situation.

Now the question is how should we respond to this kind of ominous prediction? Should we say, well, naturally an oceanographer is concerned with the ocean; what does that mean to me? If we wait for practical proof that these oceanographers, these observers are right, that the oceans may suffer biological death in 33 to 50 years, if we wait to test them in practice, it will be too late; but the ocean is an essential, irreplaceable resource for the entire earth. It seems to me the predicted collapse of ocean and ecological systems that we have heard so well explained here, although difficult to prove scientifically in advance, and seemingly remote in time, has very grave implications which call for immediate action.

Now, one basis for that is the fact that the ocean is the sink which collects all pollution. You know on the East Coast, when there is a northwest wind that blows the smog away, we all look up and breathe deeply and enjoy the fresh air. But there is one law of ecology that you have to keep in mind on that happy day, and that is that everything goes somewhere.

Where does the smog go that is blown away from Washington and New York? It goes out to sea. The rain brings it down, and it pollutes the ocean in the way that you have heard. In other words, all of the pollution which is received by the surface of the land and fresh waters, is only there temporarily. The pollution in Lake Erie goes out the Lawrence Waterway into the ocean. The pollution of the air along the eastern seaboard is blown out to sea; everything ends up in the ocean, even pollutants that temporarily are placed on the land, like insecticides, get drained out into rivers and down to the ocean.

The ocean is the sink and ultimately all pollution is ocean pollution.

Now, the thing that is misleading is it takes sometime for that transfer to take place. And also I suspect since there are so few voters that live in the ocean and relatively few on the edge, it is not brought to the attention of the administrations. So the ocean suffers, so to speak, from a poor press.

Air pollution is something that gets in everybody's lungs and eyes and they are aware of it and when it goes away, it is delivered to the ocean. So I want to make similarly a remarks here that I think the question of ocean pollution is a test of the efficacy with which we understand the entire environmental problem; that what goes away from our immediate environment ends up in the ocean, and that the death of the ocean will be the death of us all. Now there are a couple of technical points I want to make to emphasize some of the very wise observations that we have heard from Dr. Heyerdahl.

He has pointed out that the vastness of the ocean is also very misleading. So I have heard objections to the report which has been made, that 25 percent of the DDT manufactured in the world has ended up in the ocean. The point is made that even though that is a lot of DDT, there is a lot more ocean and when you divide the bulk of the ocean, the concentration is low.

Well, there is a scientific fact that I want to mention, that invalidates that kind of observation. It is related to a point that Dr. Heyerdahl made, that oil floats on water. Now many of the toxic synthetic substances that we have produced in the environment, and disseminated in the environment, such as DDT, the PCB's, and others, are, like oil, unable to dissolve in water. They are not soluble in water; they are soluble in oily substances. Now, it is an old laboratory observation, and I recall doing the experiment as a student, that if one puts a very minute amount of an oil soluble substance on a water film, that molecules line up with their ends stuck up into the air in a one-molecule thick layer. And they line up on the top surface of the water.

In other words, when we let DDT into the ocean and the PCB's, it is very likely concentrated in a submicroscopic layer at the very surface of the water, and this is precisely where, as Dr. Heyerdahl points out, a major part of the biological activity in the ocean takes place.

In other words, we cannot rely on the vast volume of the oceans to dilute DDT or PCB. Rather, it is going to become intimately concentrated on the surface of the water where it will come in contact with intense biological activities.

I was astonished the other day to find a paper which reported that in a deep sea jellyfish in the northland, thalates were detected. What are thalates? Thalates are ubiquitously used in plastics. Automobile plastic upholstery particularly contains thalates. These plasticizers are volatile and they have been shown to cause birth defects. They are now in the ocean in jellyfish. I think this emphasizes the seriousness of the roll that the ocean is playing as a sink for all of the poisons that we are producing.

Now, the main burden of my testimony is to ask this question: Given the fact that the ocean is a sink, and it is receiving all of these toxic materials, where do they come from? What fault in the way in which we are living on the earth is the basic cause for this potential catastrophe? Because I take the old fashioned view that in order to solve a problem it is a good idea to know how it arose.

Now my group at Washington University has made an analysis of this problem; I have recently written it up in my book, *The Closing Circle*, and I am submitting for the record a detailed, scientific paper which presents our evidence.

Let me summarize that for you briefly now, and draw some conclusions regarding the implications of this information for immediate action to save the ocean.

In the first place, we can show that nearly all of the pollutants that are of concern to us made their first appearance in the period of World War II or have since then increased very sharply in concentration. For example, DDT was first used during World War II; detergents appeared immediately after the war; most of the synthetic organic materials have appeared since then. In the paper I have attached I give a figure on the increase in phosphate levels.

In the 30 years preceding World War II, phosphates intruded into the surface waters of the United States about doubled. In the 30 years following World War II, approximately, level has gone up sevenfold. In other words, World War II is a watershed. It is a time when we translated many scientific developments into new technologies, but which were imposed on the environment.

Now, what I have computed is the role of the various possible factors in generating this very intense increase in pollution levels. Generally most pollutants have gone up, let's say, since 1946, between 200 and 2,000 percent. And the question that arises is what force in our society has caused that increase?

Let me give you an example of how we derived this information and then summarize it for you in general. One of the problems we are very much concerned about is the problem of pollution which arises from nitrate. Nitrate is used a great deal as a fertilizer. In the Midwest nitrate levels in surface waters have gone up in some places over the Public Health Service limits. The reason it is a problem is first it causes overgrowth of algae, and therefore pollution in rivers and lakes; and second, it raises a public health question because it is readily converted to nitrite in the intestine, particularly in infants. Nitrite combines with hemoglobin, producing a blue baby disease. This is a problem in the Midwest.

The question I raise is this: What has been the cause of the sharp increase in the intrusion of nitrate fertilizer into the U.S. environment? Now we have data, for example, between 1949 and 1968. In that period of time the total usage of inorganic nitrogen fertilizer, which in the soil is converted to nitrate, went up 648 percent. In other words, there was a 7.48-fold increase. Now why? In that period—some people say that was because we have so many more people than we did, and we have produced more food.

Well, in that period of time the U.S. population increased only 34 percent. That is not enough to account for the increase in use of fertilizer. Moreover, the amount of crop produced per capita, in other words, you might say the affluence of the United States' population with respect to food, increased only 11 percent in that period of time.

In other words, if we divided the U.S.D.A. figures on crop production by the population, we find that it increased only 11 percent in that period of time. However, the amount of nitrogen fertilizer used per unit crop production has increased fivefold.

Let's be specific. In 1949 we used 11,000 tons of fertilizing nitrogen per unit, U.S.D.A. unit, of crop production. In 1968, to produce the same amount of food, we used 57,000 tons of nitrogen fertilizer.

Remember the law of ecology, everything has to go somewhere. That extra fertilizer goes somewhere. It drains into the rivers, from the rivers into the ocean; and the point I am making very simply is that the root cause of pollution in this instance is the conversion of agricultural technology from low use of fertilizer to intense use of fertilizer. We have made an analysis of a whole series of problems of this sort.

And in each case it can be shown that of the three possible causes of pollution, increased population, increased affluence, and technological change, it is universally technological change which is the driving force. I can give you further examples and perhaps if you have inquiries about that—but let me simply go down the line.

It is the technological change from soap to detergents which has caused water pollution due to detergents and phosphates. It is the technological change from cotton and wool to nylon which has exacerbated the mercury pollution. Why? Because in order to replace the fiber, the national cotton fiber, you need energy to make a fiber; the cotton plant gets that energy free, from a perfectly renewable source—the sun, quietly, no fuss, no fumes. The cotton plant converts that energy into a fiber.

Now we brilliantly supplant that with a synthetic fiber which requires energy that we get by burning petroleum, which pollutes the air, which requires a variety of organic reactions which cause a great deal of chlorine. The result is the chlorine production in the United States has gone up about fifteenfold in this period of time.

To make chlorine, we use mercury as an electrode. Most of the mercury pollution problem in surface waters of the United States comes from the intensive use of mercury in making all of that chlorine that we use to make synthetic organic materials.

In other words, we have triggered a whole series of environmental changes. Every instance that we have examined, the automobile, the reason why we have smog is not that there are more people, not that we drive more miles—we do some—but the main thing that has happened is for every passenger mile the modern cars produce more nitrogen-dioxides than they used to, which triggers smog, emit more lead into the environment than they used to, because the car has been converted by raising the compression ratio of the engine into essentially a smog producer.

Now the next question that comes up is why have we transformed our economy in this way? One of the interesting things that we have done is to go to the Department of Commerce's census of manufacturers and to compute the changes in the growth of various industrial and agricultural technologies during the period of intense pollution. And we have made, and this is in Figure 3 of the material that I submitted to you, we have made a chart showing which technologies have grown and which have sunk in this period of time.

The picture is very clear. the cotton and wool production has gone down, synthetic—as a matter of fact, let me stop there and read to you the roster here.

The thing that has grown the fastest—it is sort of a tie, between mercury which is used for producing chlorine and no-return bottles. These have grown about 15 percent a year.

Under that we have plastics, further listing nitrogen, detergents, synthetic organic chemicals, aluminum, and so on. In other words, certain kinds of activities have grown. The tragic fact is that those activities in the United States, which have grown, with a few exceptions like color TV sets and snowmobiles, have displaced former ways of carrying out production and the new means of production is always more stressful toward the environment than the old.

I have already given you some examples. Soap has never been known to cause water pollution in hundreds and hundreds and hundreds of years of use, in many cultures. You all know of the water pollution problems which have arisen as we have displaced soap with detergents.

Some fairly trivial examples, but, I think meaningful ones: we have displaced the old beer bottle with cans. In fact, most recently we have put a flip top on the can.

Now, this has a certain benefit, I suppose it is easier to, although you may cut your finger, I suppose it is easier to have a cap opener. But we have done the following computation. We have computed the amount of fuel which needs to be burned extra to produce that aluminum top on the steel beer can. It increases the use of fuel for making the can threefold. The reason is that it takes much more energy to refine aluminum than it does steel. In other words, to pay for the convenience of the flip top on the beer can, we have tripled the air pollution due to the manufacture of a beer can.

Another computation due to a colleague at the University of Illinois is that for a throw-away bottle to deliver fluid, the same amount of fluid to a consumer to a consumer, whether beer or soda, has a returnable bottle, the throw-away bottle consumes five times more energy than the returnable one. That energy is needed to make the glass. Whenever you produce energy from fossile fuel or in any other way, you pollute the environment.

Another example, we have displaced truck traffic, truck traffic has displaced railway traffic. We have computed the fuel required to deliver a ton-mile of freight by truck and railway. It takes six times more energy, more fuel, to deliver the same freight by truck as by railroad. Now, to most of us it doesn't make any difference how an object is delivered. But we now know when it is delivered by truck, we are paying for it in air pollution.

I should add that the energy required to lay down the roadway for the trucks is four times the energy required to lay down the railroad right of way and the roadway takes a 400 foot right of way out of the land and the railway takes a 100 foot right of way. Yet we are displacing railroad traffic with truck traffic. Our economic movements is counter ecological.

I could go on and give you one example after another. Most of the major economic technological changes which have transformed U.S. production since World War II have been counter ecological and I claim this is the basic sources of the environmental crisis. It is the basic reason for the pollution of the ocean.

The next question that arises is why have we done something which on ecological grounds seems so foolish? And the answer is a very simple one which I think some of you must have already detected. Clearly, in the U.S. economy, an industry which grows has a different economic position from an industry which shrinks.

For example, we all know that the economic position of synthetic fibers is better than the economic position of cotton and wool. And, in fact, we have done a computation of the relative gross profit to be derived from pairs of technologies.

So, for example, the U.S. Department of Commerce, and we are very grateful for this, puts out a census of manufacturers with very detailed information as to the economics of various industries. It lumps together soap and detergents. So we have, for the soap and detergent industry, an indication of the economic inputs and the sales of the industry for various years. In 1946 essentially no detergents were manufactured by the industry. In that year, the gross profit—this is before taxes—the gross profit, simply the excess in returns over expenditures, was 30 percent of sales.

Now, over the years, soap has been displaced by detergents, so that at the present time about 75 percent of the market is held by deter-

gents. And from the changes in returns, one can compute that the gross profit on making detergents is 52 percent of sales. In other words, it was entirely sensible from an economic point of view for the soap and detergents industry to give up soap and to displace it with detergents, sensible for them, but not for the environment.

Other examples, steel and lumber, have been heavily displaced by new technological items, notably aluminum, plastics, and concrete. Notice how many new buildings have stressed concrete rather than steel these days. Here are some profit figures, this time for the year 1967. The steel gross profit before taxes was 12.5 percent on sales. Lumber 15.4 percent on sales.

In the other camp the displacers the more ecologically stressful things aluminum which uses a great deal of power that pollutes the air the gross profit 25.7 percent plastics 21.4 percent. Cement 37.4 percent. Now much more of this sort of analysis needs to be done but I think it is in effect self-evident that the new technologies are more profitable than the old ones and I am afraid that this explains why we have gotten into environmental trouble.

Now the reason why I have stressed this is that I want to make one final point. It has been said that the environmental issue is a motherhood issue; nobody can oppose it. And indeed we saw for those of us who have been concerned with the environment for 15 or 20 years it was a little astonishing to find how political figures hastened, some faster than others, to come into this issue.

And I think some of us wondered how soon they would discover that they were not in a motherhood issue, but something that went deeper into the most fundamental, the most difficult economic and social and political questions.

What I am concerned about now is that in my opinion—this is a personal opinion—there is now evidence that Mr. Nixon's administration has discovered that the environment is not a motherhood issue, that there is a conflict between profitability and environmental integrity, and I am afraid that he has opted for the economic system as against the ecosystem. Let me make this point: Everything that we do in our society depends on the integrity of the ecological system. Not only do the green plants produce oxygen for us to breathe, they also produce oxygen to smelt steel, to turn fuel, and indeed to run nearly all of our chemical reactions.

The ecological examples in surface waters purify the water that the chemical industry uses to run its chemical reactions. We are totally dependent on the ecosystem and I want to stress a very fundamental point, that any economic system which is incapable of living in harmony with the ecosystem cannot survive.

Any economic system which is a threat to the integrity of the ecosystem is on a suicidal course. Now, what concerns me very much today, having read this morning's newspaper about the opposition to the bill passed by the Senate unanimously, to carry out what I would regard to be a very important and essential revision of our water pollution control laws, that that bill is now being opposed by the administration, and as I thought about it, I looked back and I realized that there were a series of ecological retreats carried out by this administration.

I would say the first one was to fire Mr. Hickel. Another one was in forcing EPA to give up on the Clean Air Act standards. The third

one I mentioned, the water bill. The fourth one is the announcement by the President that we are going ahead to build two breeder reactors, when the AEC has not yet submitted the required environmental impact statement about the entire breeder program. And the last one, as of this weekend, is Amchitka.

I have to ask myself the question, why, following the statement made by Mr. Nixon early in 1970, that the environmental issue was a major one, that we had to deal with it, and I quote, "now or never," why is his administration saying not now.

The logic is if they say not now, they mean never.

Senator STEVENS. Mr. Chairman, I certainly don't like to interrupt Dr. Commoner; I know he has a great reputation, but I came here to listen to people that I thought were distinguished people in the field of ocean pollution. It appears to me that Dr. Commoner is starting to use the platform, or has used the platform for a political speech. I believe there are times, Dr. Commoner, that we have to stay within the confines of the program. I am sorry you didn't because I found your prepared statement very interesting and very informative.

I wonder if you are prepared to document the 8 years of the last administration and compare it to this administration in terms of the amount of money that has been dedicated to environmental control and antipollution activities. Can you document what was not done during the period of the build-up of the Vietnam War and other times like that.

I really am very sorry; we have run this committee on a very bipartisan basis; we are very seriously involved in an investigation into what we might do. I have had problems with Amchitka, too, but I don't know what that has to do with the subject that is before us today, nor do I know what my great friend, Wally Hickel, has to do with this subject that is before us today.

It is a very difficult position that you put those of us in who are trying to keep this on a bipartisan basis and who are trying to honestly pursue the tremendous problem we have in terms of pollution and environmental activities with which the Congress should be very much concerned.

It is probably out of line, Mr. Chairman, to interrupt Dr. Commoner, but I would be very interested if you would get to your prepared statement.

Senator HOLLINGS. Dr. Commoner, you go right ahead. I like the fact that you can gig us a little; we can move on this thing. There are views, of course, as to who has done the most and which administration. But I think it is pertinent as to where we are headed, particularly on ocean pollution. I feel that you have taken some of the most abstract and uninteresting statistics and packaged them into one of the most meaningful statements about the environment that I have ever heard. And I am enjoying it very much, even though I had thought that I had solved my textile problem, having gotten together with the Japanese, and now I find I am only causing mercury pollution down in South Carolina. But maybe that is what we ought to learn. You go right ahead.

I think you get Senator Stevens' point: we can't get into the Hickel appointment and the Amchitka blast, because then we will miss all of the fine information you have given us.

Dr. COMMONER. I appreciate Senator Stevens' position.

Senator STEVENS. I appreciate the Chairman's position, too. I thought for a while maybe he had planted you there in terms of the cotton testimony. I am sorry Senator Cook left, because I think he would have enjoyed your testimony about the beer cans. He has a little corn product in Kentucky that he would like to sell a little more of, and that might have come through.

But I am serious, Dr. Commoner; I don't think the President is involved in the statements he is taking on a political basis, and that to me is the implication of what you are saying. You are also giving the impression to the news people who are gathered here that this administration has done less than previous administrations in this field, and I would be glad to debate that with you any time, any place, because this administration has done more in the field of environmental control and antipollution activities than any administration in history.

You started off yourself by saying that the pollution didn't start overnight. I don't think Mr. Nixon caused the pollution problem any more than he caused the war problem and it seems to be he is trying to be responsible across the board in dealing with all of it.

Again, I think it would be to everyone's advantage if we would stick to the subject.

Senator HOLLINGS. Of course, more is not enough and that is why we met, and we are glad to hear from you, Dr. Commoner, I think you can take care of yourself. Go right ahead.

Dr. COMMONER. I will try to, and, Mr. Stevens, I am pretty hard to plant anywhere. In fact, you have made my point. I think I have gored about a half dozen oxen here and that is exactly the point about the environment. The environmental issue uncovers problems which in the past we have been able to keep hidden. For example, the problem of meeting unemployment. When the SST flap arose, I was kind of shocked to find that people were saying, well, we are throwing people out of jobs. The issue was why should a man take a job building something that might destroy the environment, that might wake babies up at night, couldn't we find him a better job?

It raises a whole issue of the social basis of employment. The same thing is true, incidentally, at Hiltonhead, if I may say so.

Let me go ahead. The reason why I brought up these issues is that all of us in the scientific community who have been concerned with this problem have been looking to the Congress, and to the administration to understand the issues and translate them into action. Mr. Stevens, I face students all of the time and what students want to know is the relevance of the abstract science that we teach them to their daily lives.

And it is the Congress and the President who translate that abstract science into relevance. I would be remiss as an educator if I stuck to the science without considering its relevance to important social and economic issues.

Senator STEVENS. I agree with you. That is very good. I think as the Chairman said, you have given us real food for thought. But on the other hand, when you just gore the ox sitting where you are, it seems to me some of us have responsibilities for speaking up and saying that the ox wasn't born in 1968, and I would hope you would keep partisan politics out of these comments and you certainly are not.

Dr. COMMONER. I think the difficulty is, although this Administration didn't start the problem, it does have the responsibilities of doing something about it.

Senator STEVENS. Exactly. They are doing something about it. For the first time in history, something is being done about it. I would hope maybe you would look at the positive side of that. There wasn't a Council on Environmental Quality, for instance, and there wasn't an Environmental Protection Agency. The water pollution budget is about 10 times what it was in 1968. We could go into a lot of figures, if you want to. I think that you have a great deal to offer to the hearing in terms of your expertise. That which you told us about beer cans and energy, for instance, is the kind of information we need. But I don't think we need a broad-scale attack on the President for his problems of trying to deal with unemployment, or the problems of the SST. Mr. Nixon didn't start the SST.

Dr. COMMONER. Mr. Stevens, I think the main lesson to be learned about the ocean is that it integrates with the total environment. It is the link that connects the entire environmental system. And I find it impossible to deal with any such major environmental problem without considering the environment as a whole. I find it also essential to relate the scientific analysis which I have carried out decisively, as decisively as I can, to the issues of the day. Because they will not be solved in the laboratory.

The main point of my testimony is to show you that the changes that we need to make to save the environment involve fundamental reorganizations of our economic system. That there are ecological imperatives which require that we govern what we do in industrial and agricultural production more by logical considerations than by economic ones.

That is the message that I am trying to deliver to you. I find that this has a close bearing on what I regard to be personally a slowness of the present administration to face these issues and I trace to statements which I will enter into the record, from the administration, from Mr. Stans, for example, as well, that it is all right to clean up the environment, but we have got to be careful not to upset the economic system.

The message that I am trying to deliver is that if we are not careful, we will sacrifice the environment on the altar of economic power.

Senator PASTORE. But isn't it your opinion, Doctor, that we can certainly have, with the intelligence of America, the best of two worlds? One needn't override the other. I still think we can promote our economy and at the same time promote ecology. I don't think one ought to take precedence over the other; I think we can work the two out with intelligence and patience, with the help of government.

I don't see why we can't do both.

Dr. COMMONER. That remains to be seen. For example, we will need to give up detergents for soap.

Senator PASTORE. Well, why shouldn't we?

Dr. COMMONER. I think we should.

Senator PASTORE. You still have to wash clothes, so if you don't have phosphates, you might have something else in it. We can still have clean soap, can't we?

Dr. COMMONER. Certainly.

Senator PASTORE. No one has suggested we go without washing our faces, because the soap goes down the sink.

Dr. COMMONER. The point I am making is if we replace detergents with soap and cut back on the manufacture of synthetic fabrics, for example, and restimulate the production of cotton, and become more dependent on natural rubber from abroad rather than on synthetic rubber, we will face, in my view, the most severe economic problems that this country has ever faced and I hope with you that we will learn how to face them, but I consider it my duty to tell you that, in my opinion, these will be very severe problems.

Senator PASTORE. Of course. The point is this, then, when we bring Vietnam to an end, there are going to be some displacements. At the same time, of course, like you say, Vietnam has to come to an end. I think we can take care of that displacement. I think in this whole panoramic responsibility, I think that is a challenge today, that we can do it and do it together. Let one hand help wash the other. That is the only way you can get your hands clean.

But this idea that you have got to give up one—you may temporarily have to have a slight disparity. But on the other hand, isn't that the challenge of the future? We have over 205 million Americans. They have to have a job to work at, and no one is suggesting that we have to sacrifice jobs just to promote ecology. Why can't we do both? Why can't we give people a job cleaning up the environment?

Dr. COMMONER. As a matter of fact, what we know about the relation of power utilization to the environment indicates that there will be more jobs available because one of the transformations that is taking place is that industry has become increasingly power consumptive and less dependent on labor. That is the meaning of the rise in productivity, less labor per output.

It may well be that we will have to give up our tendency to replace working hands with kilowatts.

Now, again, I think this is going to be a very serious question and I certainly fervently hope with you that we will be able to work out a harmonious way of dealing with it. But it does no service to you or to anyone else for me to hide the fact that in my view and understanding of the environmental crisis we are in is revealed the most serious consequences for our economic system.

Senator STEVENS. We certainly share that view, I think. The Toxic Substance Control Act would require pretesting and preclearance of all new chemicals before their introduction into the environment and also the test of phosphates and detergents. This bill was submitted to this committee by the administration; it is the administration's bill; it has a very worthwhile amendment by Senator Spong and I think it will soon clear this committee; Certainly we hope it will be enacted by the Congress.

But to leave the impression that the administration has not done anything, or is dragging its feet in this field, I think, is very improper, because I don't believe it is true. When you get to the problems you discussed, I would be interested in seeing sometime someone investigate what I consider to be the great polluter and that is the home furnace. It is the most inefficient burner in the whole country, and the last one we turn off, incidentally, under the current rules and regulations and laws as we run into power shortages.

The industrial users have the furnaces that are more efficient in

terms of burning the fuel and we can control pollution to a greater extent on them. Those are the first ones to turn off when we run into an energy shortage, as we did in the middle of last year. In this discussion of shortage, and I think we are going into an era of energy shortage, what you contributed in terms of the problems of beer cans and these other areas, I think are very significant.

But I don't really agree with your contribution politically.

Dr. COMMONER. Mr. Stevens, I am glad we got to a technical point on which we can disagree and that has to do with home furnaces. As it happens, the least efficient way, in terms of air pollution, to heat a home is through electric heat.

Senator STEVENS. I wasn't talking about electric heat; I was talking about gas burners.

Dr. COMMONER. They are more efficient than any other means, the reason being that—there are a few laws of physics involved here. Every time you transfer energy from one form to another, you lose something. So electric heat, for example, means heat converted to electricity and then back to heat and there is a great deal of loss.

One of the things that we need to do to alleviate the power crunch is to cut back on home, space heating, by electricity.

Senator STEVENS. I wasn't addressing myself to electricity, I was addressing myself to the fact that we put an individual gas furnace in every home in a subdivision, where if we had a central heating unit and put the heat through to the individual homes, we would have a lot more efficiency. This, apparently, seems to be the way we will go. At least I hope we will.

Senator HOLLINGS. Dr. Commoner, I will include in the record your entire statement, "The Origins of the Environmental Crisis."

Senator HOLLINGS. Does that generally conclude your remarks? I want the other Senators to have a chance to ask questions.

Dr. COMMONER. Yes, it does.

Senator HOLLINGS. Senator Hatfield?

Senator HATFIELD. Thank you very much, Mr. Chairman. As in the case of Dr. Heyerdahl, I certainly appreciate the contribution you have made this morning, Dr. Commoner.

In your testimony, you refer to the problem as subject to the economic system of two-pronged approach to productivity. How do you feel or what do you suggest would be the motivations or the requirements necessary to correct this particular issue? Is it like the chicken and the egg, as far as the public demand for products and the convenience of products and the markets meeting such demands, or is it part of the industry in creating the demand through advertising and so forth? And also, secondly, how does this tie into the socialist economic systems, such as U.S.S.R., Poland, Czechoslovakia, Hungary, and East Germany, as in the top 14 countries that are guilty of high industrial pollution? Could you comment on that?

Dr. COMMONER. Let me take the last point first:

I have discussed that in some detail in my new book. And there it is perfectly clear that in the socialist countries very similar pollution problems to the one we have, have arisen. From the little reading that I have been able to do on it, the reports are fairly scarce. It seems that they supplant our profit motive with what is called meeting the quota planned fulfillment.

In other words, a manager is told to meet certain economic goals

and then if he needs to do that at the expense of the environment, does so, by failing to put controls on and so on. So I think in both economic systems there is the same tendency to mortgage part of the productive activity on the environment. That is to take out a loan against nature. And I think that the important thing that has to be reintroduced into both economic systems is the primary necessity of maintaining the integrity of what I like to think of as our biological capital, namely, the environment.

As I point out in my book, neither the capitalist nor the socialist economic system has as yet incorporated into its theory or practice the notion that the ecological system is a primary necessity for the continuation of all economic activity. And that we dare not mortgage it if we expect to continue.

To return to the first part of the question, now, it seems to me we need to find a way of making explicit in the account books of a productive enterprise the cost which that activity imposes on a social good, namely, the environment.

Now, various proposals have been made for doing that by raising prices, taxes, and so on. Again, I don't think that is going to be a very easy solution. A very small computation was made recently on the impact of cutting back on fertilizer usage in the Midwest for the sake of preventing nitrate pollution. And it appeared there would probably be a 15 percent or so increase in food prices.

Obviously you can't do that without making further adjustments in the economic system. So that it seems to me we need to reintroduce into our economic thinking—put it this way: It is as though our economic thinking has developed without taking into account a major hidden factor, namely, the capital that we derive from the environment and which we destroy if we are not aware of what we are doing. It seems to me that economists are going to have to worry about this; they haven't paid much attention to it. You know the term placed in classical economics on environmental cost is "externalities." These are external to the considerations of the marketplace economy.

Senator PASTORE. One sure thing, Doctor, the pendulum has begun to swing in the other direction.

Dr. COMMONER. Absolutely.

Senator PASTORE. We have done more in the last 3 or 4 years than we have ever done before. America has become conscious of this. So has the Presidency. So has the Congress, and so has the public-at-large. Wouldn't you admit that?

Dr. COMMONER. Oh, yes. It seems to me the order is the other way around. The public-at-large has become convinced and the others are following.

Senator PASTORE. When you realize the magnitude of our country, and its potential, wouldn't you say that this is something that can't be done overnight?

Dr. COMMONER. Precisely. That is the way I started my testimony. You have heard very serious testimony that the oceans may be biologically dead in 35 to 50 years.

Senator PASTORE. That is right.

Dr. COMMONER. If my analysis of the cause of this is correct, namely, we have to deal with a fundamental reorganization of our economic priorities, introducing ideas which up until now have been minimized in our economic thinking, it seems to me that prudence would require

that we face this issue now and begin now so that 35 years from now the ocean will be safe.

That is precisely the point.

Senator PASTORE. In your judgment, and you are quite a student in depth, how many millions of Americans have to be put out of jobs to accomplish what you want to do?

Dr. COMMONER. None.

Senator PASTORE. That is the point I make. So why can't we have the best of two worlds? Your argument is priority should be given to ecology and forget the economy.

Dr. COMMONER. No, I didn't say that, sir.

Senator PASTORE. You intimated that more or less.

Dr. COMMONER. I am sorry to disagree with you—what I said—in fact I have been criticized for not forgetting the economy.

The point is ecological considerations raise serious economic considerations which we dare not forget. I have made this point in writing about the South Carolina situation. When that plant was blocked at Hilton Head, and the unemployed were unable to get jobs, it seems to me this raised the issue of guaranteed employment.

In other words, the point I am making is that we should not use the job issue as a way of blocking ecologically needed changes. The way to avoid that is to face an old economic, social and political issue, which is imminent.

In other words, the environment is far from a motherhood issue, it uncovers the most difficult unsolved problems that have troubled this country.

Senator PASTORE. But this is what you say in the statement, "recent statements by the President and some other administration officials led me to believe that they are so unwilling to consider changes in our economic system as to raise a danger that we will sacrifice the environment on the altar of economic dogma." That is a pretty strong statement.

Dr. COMMONER. Yes.

Senator PASTORE. Isn't that like saying "public be damned?"

Dr. COMMONER. I will now quote from Mr. Nixon's speech of September 23d this year in Detroit. He said "we are committed to cleaning up the air and cleaning up the water, but we are also committed to a strong economy and we are not going to allow the environmental issue to be used, sometimes falsely, and sometimes in a demagogic way, basically to destroy the system, the industrial system that made this the great country that it is."

Senator PASTORE. What is wrong with that statement?

Dr. COMMONER. What is wrong with it?

Senator PASTORE. I think it is a classic.

Dr. COMMONER. My criticism of that statement is that it holds our present economic system inviolate. What I think is inviolate is the ecological system. And I think that if there is a clash between them, and there is, I think the economical system must give way to the ecological system, or we won't survive.

I believe we have the competence and the intelligence to do this in a rational way; but we will never do it unless we face the issue squarely.

And that is what I am trying to do here.

Senator PASTORE. I know.

I come back to what I said, I think Mr. Nixon said let's do both. That is what that statement means to me.

Senator HATFIELD. Mr. Chairman?

Senator HOLLINGS. Senator Hatfield?

Senator HATFIELD. Actually, Dr. Commoner, aren't we sort of involved here in semantics? Because if you look at the comments that I have read at least in your paper on page 3, are you not asking the public to forgo products; are you not asking us to return to a pristine, primitive society?

You are showing some options that we have in terms of whether we want to use soap or detergents, rail travel or truck travel, and in many ways you are actually suggesting here, as I see it, more employment, because there was a definite impact on this whole pattern of labor costs that were a part of the motivation behind the new technology.

Dr. COMMONER. Exactly.

Senator HATFIELD. So consequently I don't think it has to be "either/or." I don't interpret this as an "either/or." I see it as giving us the statistical evidence showing the dangers we now are encountering, because we have moved to these various plastics and substitute products, at an expense to our environment. It is not a matter of not keeping clean or of keeping clean; it is not a matter of stopping all transportation or expanding transportation. It is just a matter of choice here.

You make the comments that you have, that within 35 to 50 years the oceans may become barren. I sat in the Dartmouth Conference in Kiev last summer and listened to Dr. Peterhof, the atmospheric scientist from the Soviet Union say within 50 years the atmosphere will be totally unliveable for human beings. We will face this situation confronting us with the ocean and the atmosphere. I think you have made a tremendous contribution here to jar us enough to face up to some of these decisions that the scientists cannot make, that only the politicians can make, and we have to face up to these hard decisions and make some choices.

We also must stop this polarized thinking, driving people into extreme positions, rather than trying to reconcile, these various needs of man with the choices we have to meet those needs. I think you have made a tremendous contribution. I thank you for it.

Dr. COMMONER. Thank you, Mr. Hatfield. You have summarized my position very well.

The only thing I would add is that we have to go notice that some of the things that give way will be in the realm of economics and you are absolutely right, that is not the scientists' business. In effect what I am trying to do is turn the problem over to you.

Senator HATFIELD. Let me give you an example, Mr. Chairman. This same Commerce Committee has been holding meetings, the Subcommittee on Environment, and we have been talking about the problems of new chemicals coming into the market, and we are considering legislation here, as may have already been introduced into the record, that would require pretesting and preclearance for new chemicals under the Toxic Substances Act, which I think is an appropriate role for government.

Of course, this is taking the situation as of today and looking ahead. But we have to go back and try to un-do some things that have been

improperly done. I think this is an example of what you are saying: We have to utilize the power of government to set these priorities and help make those choices.

Dr. COMMONER. Exactly. Absolutely.

Senator PASTORE. Well, I endorse the Hatfield speech.

Senator HOLLINGS. Dr. Commoner, I have been rather silent, because we want to move on and hear Mr. Downs, but you have made a very brilliant contribution. I have worked both sides of the aisle, government and industry. I have brought new jobs and new industry into my State. I worked on this pollution problem with the BASF in Beaufort, South Carolina. They had no idea of compliance. And when they started writing letters to me that they were going to comply with the law, really they were trying to evade and avoid coming up with plans that we could present to the Department of Interior. In turn there are many more jobs down there with the fisheries, with the development of tourism, and other opportunities in this particular area than BASF would have provided to the very low income citizens.

Specifically we all know that the oceans program is dragging its feet. It dragged its feet under President Kennedy. It dragged its feet under President Johnson. It was due to this Congress that we got the Stratton Commission and President Nixon instituted NOAA.

We had a conference last week on how we could get the Administration going again in giving attention to the oceans, giving attention to the pollution problem, as the President gave in his Reorganization Plan No. 4 setting up the National Oceanic and Atmospheric Administration. So we are trying to move it along, and you have helped us in a magnificent way.

Let me ask this, because you are now talking about population, and, really, that new technology has caused the population explosion since World War II. What answer do I give to the argument that it is just a newly discovered subject, that we have been having this pollution all of the time?

What is that answer to that?

Dr. COMMONER. The answer is in the data, some of which is summarized in the paper I submitted for the record. I think the phosphate story is perfectly clear. It is true that as we have disposed of more and more sewage into surface waters, the phosphate levels have gone up. But as I pointed out, in 30 years before World War II, the phosphate level about doubled. In the time since World War II, phosphate levels have gone up sevenfold.

In other words, we have in many cases introduced wholly new pollutants, man-made radioactivity, all of the synthetic materials; they are all really postwar; the use of intense fertilizer—again the nitrogen picture is a very gradual rise in the use of fertilizer up to the war and then about a tenfold increase.

So that the actual data show that the impact on the environment has gone up by an average of tenfold since 1946. All you have to do is just look at the actual numbers. I think that is the answer.

Now the other side of it is that, yes, we have been carrying out activities such as burning garbage and dumping sewage into the water, and there is a limit to the insult that you can impose on an ecosystem. And we are beginning to run out of ecosystems to destroy.

So that the other reason for the sharp change is that we have used

up the mortgage credit that we have in the environment. And here, too, it means that there has been a decisive change in the last 25 years.

Senator HOLLINGS. What, in your opinion, would be needed on a worldwide basis to save the oceans?

Dr. COMMONER. It seems to me that the kind of economic reorganization that I tried to outline in the United States, namely, redoing the technological transformation of our industry and agriculture since the war, in a proecological way. That has to be applied, it seems to me, to every industrial nation of the world. But in order to do that, they will have to change their relationships with the developing countries.

For example, if we were to give up synthetic fibers in favor of natural ones, the ecologically sensible place to get our cotton from would be some of the developing countries, such as Egypt and India; or, take a very sharp example: We pollute the environment in part by making synthetic rubber for the reasons I have already given. That can be replaced by natural rubber, but we can't produce it in the United States. We would have to get the natural rubber from tropical countries. But they are interested in their technological development and what I favor—and this again is something I discussed in my new book—would be for Malasia, for example, not to export rubber, but tires.

In other words, we would have to reorganize the dependence of one nation on another in a way which makes sense ecologically, and again, I must tell you honestly that I am aware that the ecological sense would look to a military man, for example as a disaster. Imagine saying that we have to be dependent on Malasian tires for our equipment! And again, I think there is no sense in ducking the fact that if we want to be ecologically rational, we are going to have to face the most severe economic, social and political questions that the world has ever faced.

And in order to re-do the relationships among countries, we will have to solve some of these despite the political problems which I think we have just seen in a trivial way in the textile situation.

Just one other point I want to make, and that is again that when you look seriously at any environmental issue, what it does is to uncover the most difficult economic, social and political problems that we have managed to forget. You look at ecology and you realize we cannot tolerate the entire notion of nuclear weapons. You look at the ecology and you realize we can't tolerate the kind of trade barriers that have sprung up.

You look at the ecology and you realize that we cannot tolerate the unemployment situation. Right down the line.

Now, what I am pleading with you is to pick up from us in the scientific community this issue which belongs in the hands of the Congress and the public rather than in the academic community.

Senator HOLLINGS. We thank you very, very much.

Senator STEVENS. Yes. I would not want the record to indicate I disagree with you on that. I hope that you understand that. I just cannot understand that the academic community should become overly partisan in approaching the subject, that is all.

Senator HOLLINGS. Well, let the record show that Dr. Commoner is the first witness we have had up here who has had a kind word for railroads.

(The statement follows:)

REVISED

## THE ORIGINS OF THE ENVIRONMENTAL CRISIS

Keynote Address before the Council of Europe, Second Symposium of  
Members of Parliament Specialists in Public Health.

by

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It is now widely appreciated that the world is face to face with an environmental crisis. We now know that environmental pollution is not only an affront to the senses and a threat to human health. More seriously, environmental degradation is a sign that the global ecosystem--which supports all life and all human activities--is under stresses which, if not relieved, will eventually destroy it. We now know the full, grim truth: what is at risk in the environmental crisis is human survival.

Clearly every inhabitant of the earth ought to have an equal interest in the integrity of the environment. However, in reality there are sharp differences in national attitudes toward the issue. Especially in relation to the forthcoming 1972 United Nations Conference on the Human Environment, a striking conflict between the attitudes of industrialized and developing nations toward the environmental crisis has developed. This divergence is understandable. Three main factors are involved in environmental pollution: growth of population; increased affluence, or production per capita; the introduction of new technology. The conflict has arisen because each of these factors has a sharply different import for industrialized and developing nations.

A commonly voiced--and, as I shall try to show, largely erroneous--idea is that environmental pollution is chiefly due to the pressure of growing population and affluence on the limited resources available from the ecosystem. On these grounds it is often asserted that control of population growth and reduction in per capita consumption are essential if environmental collapse is to be avoided. This is a foreboding outlook for the developing nations, which are struggling to sustain rapidly rising populations, and to increase the exceedingly low levels of consumption of their peoples.

At the same time, it is pointed out that environmental deterioration is also the consequence of modern production technologies, which, as presently designed, release massive amounts of pollutants into the environment. On these grounds developing nations are sometimes advised to be wary of modern industrialization. This advice conflicts with their intense desire to bring to their peoples the material advantages which have already accrued to industrialized nations from technology.

Given such a view of the origins of the environmental crisis, the interests of industrialized and developing nations toward environmental problems do appear to be in sharp conflict. If unresolved, this conflict may have tragic effects on the urgent and difficult task, which is essential to the welfare of both industrialized and developing nations, of closing the growing gap between the quality of life enjoyed by the rich and the poor, wherever they live.

However, I believe that this conflict reflects a faulty analysis of the environmental crisis. In the analysis which follows I shall try to show why the effects of population growth and increased affluence on environmental deterioration have been seriously misconstrued and that these factors need not hinder the legitimate desire of developing countries to improve the lot of their people. Moreover, I shall propose that a fundamental solution of the environmental crisis will require that the present technological dependence of developing nations on industrialized ones be reversed in certain significant respects. Like the ecosystem itself, the environmental crisis is a global problem which demands global solutions.

In order to analyze the origins of environmental degradation it is essential to begin with an understanding of the properties of the environment. These may be summarized as follows:

## The Ecosphere

1) The environment is defined as a system comprising the earth's living things and the thin global skin of air, water and soil which is their habitat.

2) In nature, this system, the ecosphere, is the product of the joint, interdigitated evolution of living things and of the physical and chemical constituents of the earth's surface. On the time scale of human life the evolutionary development of the ecosphere has been very slow and irreversible. Hence, the ecosphere is irreplaceable; if it should be destroyed, it could never be reconstituted or replaced either by natural processes or by human effort.

3) The basic functional element of the ecosphere is the ecological cycle, in which each separate element influences the behavior of the rest of the cycle, and is in turn itself influenced by it. For example, in surface waters fish excrete organic waste, which is converted by bacteria to inorganic products; in turn, the latter are nutrients for algal growth; the algae are eaten by the fish, and the cycle is complete. Such a cyclical process accomplishes the self-purification of the ecosystem, in that wastes produced in one step in the cycle become the necessary raw materials for the next step. Such cycles are cybernetically self-governed, dynamically maintaining a steady state condition of indefinite duration. However if sufficiently stressed by an external agency, the ecosystem may exceed the limits of self-adjustment and eventually collapse. Thus, if the aquatic cycle is overloaded with organic animal waste, the amount of oxygen needed to support waste decomposition by the bacteria of decay may be greater than the oxygen available in the water. The oxygen level is then reduced to zero; lacking oxygen, the bacteria die and this phase of the cycle stops, halting the cycle as a whole.

4) Human beings are dependent on the ecosphere not only for their biological requirements (oxygen, water, food) but also for resources which are essential to all productive activities. These resources, together with underground minerals, are the irreplaceable and essential foundation of all human societies.

5) If we regard economic processes as the means which govern the disposition and use of resources available to human society, then it is evident from the above that the continued availability of those resources which are derived from the ecosphere (i. e., non-mineral resources), and therefore the stability of the ecosystem, is an essential prerequisite for the success of any economic system. More bluntly, any economic system which hopes to survive must be compatible with the continued operation of the ecosystem.

6) Because the turnover rate of an ecosystem is inherently limited, there is a corresponding limit to the rate of production of any of its constituents. Different segments of the global ecosystem (e.g., soil, fresh water, marine ecosystems) operate at different intrinsic turnover rates and therefore differ in the limits of their productivity. On purely theoretical grounds it is self-evident that any economic system which is impelled to grow by constantly increasing the rate at which it extracts wealth from the ecosystem must eventually drive the ecosystem to a state of collapse. Computation of the rate limits of the global ecosystem or of any major part of it are, as yet, in a rather primitive state. Apart from the foregoing theoretical and as yet unspecified limit of economic growth, such a limit may arise much more rapidly if the growth in the output of goods by the economic system is dependent on productive technologies which are especially destructive of the stability of the ecosystem. As will be shown below this is precisely the situation in a modern, industrialized country such as the United States.

7) Unlike all other forms of life, human beings are capable of exerting environmental effects which extend, both quantitatively and qualitatively, far beyond their influence as biological organisms. Human activities have also introduced into the environment not only intense stresses due to natural agents (such as ecologically-misplaced bodily wastes), but also wholly new substances not encountered in natural environmental processes: artificial radioisotopes, detergents, pesticides, plastics, a variety of toxic metals and gases, and a host of man-made, synthetic substances. These human intrusions on the natural environment have thrown major segments of the ecosystem out of balance.

8) Environmental pollution is the symptom of the resultant breakdown of the environmental cycles. The fouling of surface waters is largely the result of overloading the natural, limited cycle of the aquatic ecosystem either by direct dumping of organic matter, in the form of sewage and industrial wastes, or indirectly by the release of algal nutrients produced by waste treatment, or leached from over-fertilized soil. Water pollution is a signal that the natural, self-purifying aquatic ecological cycle has broken down. Similarly, air pollution is a sign that human activities have overloaded the self-cleansing capacity of the weather system to the point at which the natural winds, rain, and snow are no longer capable of cleaning the air. The deterioration of the soil shows that the soil system is being over-driven, that organic matter, in the form of food, is being extracted from the cycle at a rate which exceeds the rate of rebuilding of the soil's humus. The technical expedient of attempting to evade this problem by loading the soil with inorganic fertilizer is capable of restoring the crop yield--but at the expense of increasing pollution of

the water and the air. Pollution by man-made synthetics, such as pesticides, detergents and plastics, and by the dissemination of materials not naturally part of the environmental system, such as lead and mercury, is a sign that these materials cannot be accommodated by the self-purifying capabilities of the natural system. As a result they accumulate in places harmful to the ecosystem and to man.

### The Pollution Problem

The environmental crisis tells us that there is something seriously wrong with the way in which human beings have occupied their habitat, the Earth. It confronts us with the need to specify what has gone wrong and why. Clearly, the fault must be due to human activities: the growth of population, the nature of science and technology, the means of producing, accumulating, distributing and using the wealth extracted from the earth's natural system. For no one has argued, to my knowledge, that the recent intensification of pollution on the earth is the result of some change in the natural sector, independent of man. Indeed the few remaining areas of the world that are relatively untouched by the powerful hand of man are, to that degree, free of smog, foul water and deteriorating soil. We must seek, then, to account for environmental deterioration by finding its functional relationship to human activities on the earth.

One explanation that is sometimes advanced is that man is a "dirty" animal--that unlike other animals man is likely to "foul his own nest." Somehow, according to this view, man lacks other animals' tidy nature, so that environmental pollution increases with the growth of the human population.

This explanation is basically faulty, for the "neatness" of animals in nature is not the result of their own sanitary activities. On the contrary, no animal, or any other living thing, for that matter, acts on its own wastes. What removes these wastes is the activity of other living things, which use them as nutrients. The reason why wastes do not accumulate in a natural non-human situation is that there are no "wastes" in the sense that everything produced by one type of animal, plant or microorganism is used by some other living thing. As long as these cyclical relations remain unbroken, no substance, no waste can accumulate. Human beings pollute the environment only because their activities have broken out of the closed, cyclical network in which all other living things are held.

Indeed, at least on the relatively short time-scale that is involved in our present pollution problems, no living thing that is itself part of an ecosystem can possibly degrade it for the system's circularity enables it to adjust, automatically, to changes that arise from within. It is stressed, or polluted, usually by an outside agency. Thus, so long as human beings

held their place in the terrestrial ecosystem--consuming food produced by the soil, oxygen released by plants, returning organic wastes to the soil and carbon dioxide to the plants--they could do relatively little ecological harm. However, once removed from this cycle, for example to a city, so that bodily wastes are not returned to the soil but to surface water, the population is separated from the ecosystem of which it was originally a part. Now the wastes become an external stress on the aquatic system into which they intrude, overwhelm the system's self-adjustment, and pollute it. Environmental pollution is therefore generated not so much by human biological activities, as by human social activities; agriculture industry, transportation and urbanization--which greatly distort the impact of man's biological effects on a multiplicity of natural cycles, and introduce, as well, a number of unnatural effects.

Certain human activities, for example, agriculture, forestry and fishing, represent direct exploitation of the productivity of a particular ecosystem. In these cases, a constituent of the ecosystem which has economic value--for example, an agricultural crop, timber or fish--is withdrawn from the ecosystem. This represents an external drain on the system which must be carefully adjusted to natural and man-made inputs to the ecosystem if collapse is to be avoided. Examples include the destructive erosion of agricultural or forest lands following overly-intense exploitation, or the incipient destruction of the whaling industry due to the extinction of whales.

Environmental stress may also arise if the amount of a particular ecosystem component is deliberately augmented from without, either to dispose of human waste or in an effort to accelerate the system's rate of turnover and thereby increase the yield of an extractable good. An example of the first sort is the dumping of sewage into surface waters. An example of the second sort is the use of fertilizer nitrogen in agriculture.

Finally, environmental degradation may be due to the intrusion into an ecosystem of a substance wholly foreign to it. Perhaps the simplest example is a synthetic plastic, which unlike natural polymers is incapable of being degraded by decay microorganisms, and therefore persists as rubbish or is burned--in both cases causing pollution. In the same way, if a toxic substance such as mercury or lead, which plays no role in the chemistry of life and interferes with the actions of substances which do, intrudes at a sufficient concentration on an ecosystem it is bound to cause damage. Hence, any productive activity which introduces substances that are foreign to the natural environment runs a significant risk of polluting it.

### The Origins of Environmental Impacts

Our task, then, is to discover what activities of human society generate environmental impacts--that is, pollutants foreign to the ecosystem which tend to degrade its capacity for self-adjustment.

In what follows, I wish to report the results of an initial effort in this direction, which is based on an analysis of the environmental situation in one of the most intensely polluted areas of the globe--the United States.<sup>1</sup> In the United States most pollution problems are of relatively recent origin. The post-war period, 1945-46, is a convenient benchmark, for a number of pollutants--man-made radioisotopes, detergents, plastics, synthetic pesticides and herbicides--are due to the emergence, after the war, of new productive technologies. The statistical data available for this period in the United States provide a useful opportunity to compare the changes in the levels of various pollutants with the concurrent activities of the United States productive system that might be related to their environmental effects.

Although, unfortunately, we lack sufficient comprehensive data on the actual environmental levels of most pollutants in the United States, some estimates of historical changes can be made from intermittent observations, and from computed data on emissions of pollutants from their sources. Some of the available data are summarized in Table I, which indicates that since 1946, emissions of pollutants have increased by 200-2000%. In the case of phosphate, which is a pollutant of surface waters, and enters mainly from municipal sewage, data on the long term trends are available; these are shown in Figure 1. In the 30-year period between 1910 and 1940 phosphorus output from municipal sewage increased gradually from about 17 million lbs. /year to about 40 million lbs. /year. Thereafter the rate of output rose rapidly; so that in the 30-year period 1940-1970 phosphorus output increased to about 300 million lbs. /year.

It should be noted that these are data regarding the computed emission of pollutants, which are not necessarily descriptive of their actual concentrations in the environment or of their ultimate effects on the ecosystems or on human health. Numerous, complex and interrelated processes intervene between the entry of a pollutant into the ecosystem and the expression of its biological effect. Moreover, two or more pollutants may interact synergistically to intensify the separate effects. Most of these processes are still too poorly understood to enable us to convert the amount of a pollutant entering an ecosystem to a quantitative estimate of its degradative effects. Nevertheless it is self-evident that these effects (such as the incidence of respiratory disease due to air pollutants, or of algal overgrowths due to phosphate and nitrate) have increased sharply,

along with the rapid rise of pollutant levels, since 1946. Since pollutant emission is a direct measure of the activity of the source, it is a useful way to estimate the contributions of different sources to the overall degradation of the environment.

If we define the amount of a given pollutant introduced annually into the environment as the environmental impact (I), it then becomes possible to relate this value to the effects of three major factors that might influence the value of I by means of the following identity:

$$I = \text{Population} \cdot \frac{\text{Economic Good}}{\text{Population}} \cdot \frac{\text{Pollutant}}{\text{Economic Good}}$$

Here Population refers to the size of the United States population in a given year, Economic Good refers to the amount of a designated good produced (or where appropriate, consumed) during the given year, and Pollutant refers to the amount of a specific pollutant (defined as above) released into the environment as a result of the production (or consumption) of the designated good, during the given year. This relationship enables the estimation of the contribution of three factors to the total environmental impact: (a) the size of the population; (b) production (or consumption) per capita, i.e., "affluence;" (c) the environmental impact (i.e., amount of pollutant) generated per unit of production (or consumption), which reflects the nature of the productive technology.

Since we are concerned with identifying the sources of the sharp increases in the environmental impacts experienced in the United States in the period 1946-present, it becomes of interest to examine the concurrent changes in the nation's productive activities. The most general data relevant to these changes are presented in Figure 2. In the period 1946-68 United States population has increased, at an approximately constant rate by about 42%; GNP (adjusted to 1958 dollars) has increased exponentially by about 126% in that period; GNP per capita has also increased approximately exponentially by about 59%.

We can see at once that, as a first approximation, the contribution of population growth to the overall values of the environmental impacts generated since 1946 is of the order of 40%. In most cases, this represents a relatively small contribution to the total environmental impact, since as indicated in Table I, these values increased by 200-2000%, in that period of time.

In order to evaluate the effects of the remaining factors it is useful to examine the growth rates of different sectors of the productive economy. For this purpose a series of productive activities which are likely to contribute significantly to environmental impact and are representative of the overall pattern of the economy have been selected. From the annual production (or where appropriate, consumption) data for the United States as a whole, which are available from government statistical reports, the annual percentage rates of increase or decrease are calculated, by computer. The results of these computations are presented in Figure 3, from which it is possible to derive certain useful generalizations about the pattern of economic growth, which are relevant to environmental impacts, in the United States.

a) Production and consumption of certain goods have increased at an annual rate about equal to the annual rate of increase of the population, so that per capita production remains essentially unchanged. This group includes food, fabric and clothing, major household appliances and certain basic metals and building materials, including steel and copper, and brick. In effect, with respect to these basic items average "affluence," i. e., per capita production (or consumption) has remained essentially unchanged in 1946-68.

b) The annual production of certain goods has decreased since 1946, or has increased at an annual rate below that of the population. Horsepower produced by work animals is the extreme case; it declined at an annual rate of about 10%. Other items in this category are: saponifiable fat, cotton fiber, wool fiber, lumber, milk, railroad horsepower, and railroad freight. These are goods which have been significantly displaced in the pattern of production during the course of the overall growth of the economy. Cultivated farm acreage also declined in this period.

c) Among the productive activities which have increased at an annual rate in excess of that exhibited by the population, the following classes can be discerned:

i) Certain of the rapidly increasing productive activities are substitutes for activities that have declined in rate, relative to population. These generally represent technological displacement of an older process by a newer one, with the sum of goods produced remaining essentially constant, per capita, or increasing somewhat. These displacement processes include the following: (a) natural fibers (cotton and wool) by synthetic fibers; (b) lumber by plastics;

(c) soap by detergents; (d) steel by aluminum and cement; (e) railroad freight by truck freight; (f) harvested acreage by fertilizer; (g) returnable by non-returnable bottles.

ii) Certain of the rapidly growing productive activities evident in Fig. 3 are secondary consequences of displacement processes. Thus the displacement of natural products by synthetic ones involves the use of much increased amounts of synthetic organic chemicals, so that, this category has increased sharply. Moreover, since many organic syntheses require chlorine as a reagent, the rate of chlorine production has also increased rapidly. Finally, because chlorine is efficiently produced in a mercury electrolytic cell, the use of mercury for this purpose has also increased at a very considerable rate. Similarly, the rapidly rising rate of power utilization is, in part, a secondary consequence of certain displacement processes, for a number of the new technologies are more power-consuming than the technologies which they replace.

iii) Finally, among the rapidly growing productive activities evident in Fig. 3 are some which represent neither displacements of older technologies, nor sequelae to such displacements, but true increments in per capita availability of goods. An example of this category is consumer electronics (radios, television sets, sound equipment, etc.). Such items represent true increases in "affluence."

In sum, the pattern of growth in the United States economy in 1946-68 may be generalized as follows. Basic life necessities, representing perhaps 1/3 of the total GNP, have grown in annual production at about the pace of population growth, so that no significant overall change in per capita production has taken place in this period. However, within these general categories of goods--food, fiber and clothing, freight haulage, household necessities--there has been a pronounced displacement of natural products by synthetic ones, of power-conservative products by relatively power-consuming ones, of reusable containers by "disposable" ones.

Given the foregoing data we can now determine the relative costs, in intensity of environmental impact, of the several distinctive features of the growth of the United States economy from 1946 to the present. An examination of this question reveals that most of the sharp increases in environmental impact which have occurred in the United States since 1946 result from the introduction of new productive technologies which generate more severe environmental impacts than the technologies which they replace. The relevant data are presented in what follows:

### 1) Agricultural Production

As shown in Fig. 3, agricultural production in the United States, as measured by the U. S. Department of Agriculture Crop Index, has increased at about the same rate as the population since 1946. However, the technological methods for achieving agricultural production have changed significantly in that period. One important change is illustrated by Fig. 4, which shows that although agricultural production per capita has increased only slightly, harvested acreage has decreased, and the use of inorganic nitrogen fertilizer has risen sharply. This displacement process--i. e. of fertilizer for land--leads to a considerably increased environmental impact.

Briefly stated the relevant ecological situation is the following.<sup>3</sup> Nitrogen, an essential constituent of all living things, is available to plants in nature from organic nitrogen, stored in the soil in the form of humus. Humus is broken down by bacteria to release inorganic forms of nitrogen, eventually as nitrate. The latter is taken up by the plant roots and reconverted to organic matter, such as the plant's protein. Finally the plant may be eaten by a grazing animal, which returns the nitrogen not retained in the growth of its own body to the soil as bodily wastes.

Agriculture imposes a negative drain on this cycle; nitrogen is removed from the system in the form of the plant crop or of the livestock produced from it. In ecologically sound husbandry all of the organic nitrogen produced by the soil system, other than the food itself--plant residues, manure, garbage--is returned to the soil, where it is converted by complex microbial processes to humus and thus helps to restore the soil's organic nitrogen content. The deficit, if it is not too large, can be made up by the process of nitrogen fixation--in which bacteria, usually in close association with the roots of certain plants, take up nitrogen gas from the air and convert it into organic form. If the nitrogen cycle is not in balance, agriculture "mines" the soil nitrogen, progressively depleting it. This process does more than reduce the store of organic nitrogen available to support plant growth, for humus is not only a nutrient store. Due to its polymeric structure humus is also responsible for the porosity of the soil to air. And air is essential to the soil, not only as a source of nitrogen for fixation, but also because its oxygen is essential to the root's metabolic activity, which in turn is the driving force for the absorption of nutrients by the roots. In the United States, for example in Corn Belt soils, about 1/2 of the original soil organic nitrogen has been lost since 1880. Naturally, other things being equal, such soil is relatively infertile and produces relatively poor crop yields.

However, beginning after World War II a technological solution was intensively applied to this problem: sharply increasing amounts of inorganic nitrogen were applied to the soil in the form of fertilizer. Annual nitrogen fertilizer usage in the United States increased about 14-fold between 1946 and 1968.

In effect, then, nitrogen fertilizer can be regarded as a substitute for land. With the intensive use of fertilizer it becomes possible to accelerate the turnover rate of the soil ecosystem, so that each acre of soil annually produces more food than before. The economic benefits of this new agricultural technology are appreciable, and self-evident. However, this economic advantage may be counterbalanced by the increased impact on the environment. This arises because, given the reduced humus content of the soil, the plant's roots do not efficiently absorb the added fertilizer. As a result an appreciable part leaches from the soil as nitrate and enters surface waters where it becomes a serious pollutant. Nitrate may encourage algal overgrowths, which on their inevitable death and decay tend to break down the self-purifying aquatic cycle.

Excess nitrate from fertilizer drainage leads to another environmental impact, which may affect human health. While nitrate in food and drinking water appears to be relatively innocuous, nitrite is not, for it combines with hemoglobin in the blood, converting it to methemoglobin-- which cannot carry oxygen. Unfortunately nitrate can be converted to nitrite by the action of bacteria in the intestinal tract, especially in infants, causing asphyxiation and even death. On these grounds, the United States Public Health Service has established 10 ppm of nitrate nitrogen as the acceptable limit of nitrate in drinking water. In a number of agricultural areas in the United States nitrate levels in water supplies obtained from wells, and in some instances from surface waters have exceeded this limit. Our own studies in the area of Decatur, Illinois show quite directly that in the spring of 1970 when the city's water supply, which is derived from an impoundment of the Sangamon River, recorded 9 ppm of nitrate nitrogen, a minimum of 60% of the nitrate was derived from inorganic fertilizer applied to the surrounding farmland.<sup>4</sup>

The effect of this change in agricultural technology is evident from Table II, which compares the influence of the several relevant factors on the total environmental impact due to fertilizer nitrogen in 1949 and 1968. During that period the total annual use of fertilizer nitrogen, i. e. the total environmental impact, increased 648 percent. The influence of population size increased by 34%; the influence of crop production per capita

("affluence") increased by 11%; the influence of the change in fertilizer technology increased by 405%. Clearly the last factor dominates the large increase in the total environmental impact of fertilizer nitrogen. Specifically, it should be noted that in 1949 about 11,000 tons of fertilizer nitrogen were used per unit crop production, while in 1968 about 57,000 tons of nitrogen were employed for the same crop yield. This means that the efficiency with which fertilizer nitrogen contributes to crop yield has declined 5-fold. Obviously an appreciable part of the added nitrogen does not enter the crop and must appear elsewhere in the ecosystem.

The biological basis for this effect is shown in Figure 5, which compares the corn yield in the State of Illinois, with the concurrent amounts of nitrogen fertilizer added to the soil.<sup>5</sup> This shows that as fertilizer levels increased the yield per acre rose, but eventually leveled off due to the natural limits of plant growth. Thus, between 1962 and 1968, fertilizer usage doubled, but crop yield rose only about 10-15%. Clearly at the higher levels of fertilizer usage an increasingly small proportion of the fertilizer contributes to the crop. As indicated earlier, the remainder leaches into surface waters where it causes serious pollution problems. Thus, this innovation in agricultural technology sharply increases the environmental stress due to agricultural production.

A similar situation exists in the case of pesticides. This is shown by the changes in the environmental impact index of pesticides between 1950 and 1967 (Table III). In that time there was a 168% increase in the amount of pesticides used per unit crop production, as a national average. By killing off natural insect predators and parasites of the target pest, while the latter often becomes resistant to insecticides, the use of modern synthetic insecticides tends to exacerbate the pest problems that they were designed to control. As a result increasing amounts of insecticides must be used to maintain agricultural productivity. For example, in Arizona insecticide use on cotton tripled between 1965 and 1967, with no significant change in yield. Insecticide usage is, so to speak, self-accelerating--resulting in both a decreased efficiency and an increased environmental impact.

Another technological displacement in agriculture is the increased use of feedlots for the production of livestock in preference to range feeding. Range-fed cattle are integrated into the soil ecosystem; they graze the soil's grass crop and restore nutrient to the soil as manure. When the cattle are maintained instead in huge pens, where they are fed on corn and deposit their wastes intensively in the feedlot itself, the wastes do not return to

the soil. Instead the waste drains into surface waters where it adds to the stresses due to fertilizer nitrogen and detergent phosphate. The magnitude of the effect is considerable. At the present time the organic waste produced in feedlots is more than the organic waste produced by all the cities of the United States. Again, the newer technology has a serious environmental impact, and in this case has displaced a technology with an essentially zero environmental impact.

2) Textiles: Figure 6 describes changes in textile production since 1946. While total fiber production per capita has remained constant, natural fibers (cotton and wool) have been significantly displaced by synthetic ones. This technological change considerably increases the environmental impact due to fiber production and use.

One reason is that the energy required for the synthesis of the final product, a linear polymer (cellulose in the case of cotton, keratin in the case of wool and polyamides in the case of nylon) is greater for the synthetic material. Although quantitative data are not yet available, this is evident from the comparison of two productive processes provided by Table IV. Nylon production involves as many as 10 steps of chemical synthesis, each requiring considerable energy in the form of heat and electric power to overcome the entropy associated with chemical mixtures and to operate the reaction apparatus. In contrast, energy required for the synthesis of cotton is derived, free, from a renewable source--sunlight--and is transferred without combustion and resultant air pollution. Moreover, the raw material for cellulose synthesis is carbon dioxide and water, both freely available renewable resources, while the raw material for nylon synthesis is petroleum or a similar hydrocarbon--non-renewable resources. As a result it would appear that the environmental stress due to the production of such an artificial fiber is probably well in excess of that due to the production of an equal weight of cotton. This is only an approximation, for we need far more detailed, quantitative estimates, in the form of the appropriate environmental impact indices, that would also take into account the fuel and other materials used in the production of cotton.

Because a synthetic fiber such as nylon is unnatural, it also has a greater impact on the environment as a waste material, than do cotton or wool. The natural polymers in cotton and wool, cellulose and keratin, are important constituents of the soil ecosystem. Through the action of molds and decay bacteria they contribute to the formation of humus--a substance which is essential to the natural fertility of the soil. In this process cellulose is readily broken down in the soil ecosystem. Thus, in nature, cellulose and keratin are simply not "wastes", because they provide essential nutrients for soil microorganisms. Hence they cannot accumulate.

This results from the crucial fact that for every polymer which is produced in nature by living things, there exist in some living things enzymes which have the specific capability of degrading that polymer. In the absence of such an enzyme the natural polymers are quite resistant to degradation, as evident from the durability of fabrics which are protected from biological attack.

The contrast with synthetic fibers is striking. The structure of nylon and similar synthetic polymers is a human invention and does not occur in natural living things. Hence, unlike natural polymers, synthetic ones find no counterpart in the armamentarium of degradative enzymes in nature. Ecologically, synthetic polymers are literally indestructible. Hence, every bit of synthetic fiber or polymer that has been produced on the earth is either destroyed by burning--and thereby pollutes the air--or accumulates as rubbish. One result, according to a recent report, is that microscopic fragments of plastic fibers often red, blue or orange have now become common in certain marine waters.<sup>6</sup> For technological displacement has been at work in this area too; in recent years natural fibers such as hemp and jute have been nearly totally replaced by synthetic fibers in fishing operations. A chief reason for this use of synthetic fibers is that they resist degradation by molds, which, as already indicated readily attack cellulosic net materials such as hemp or jute. Thus, the property which enhances the economic value of the synthetic fiber over the natural one--its resistance to biological degradation--is precisely the property which increases the environmental impact of the synthetic material.

### 3) Detergents

Figure 7 shows that synthetic detergents have largely replaced soap in the United States as domestic and industrial cleaners, with the total production of cleaners per capita remaining essentially unchanged. Soap is based on a natural organic substance, fat, which is reacted with alkali to produce the end product. Being a natural product, fat is extracted from an ecosystem (for example that represented by a coconut palm plantation), and when released into an aquatic ecosystem after use, soap is readily degraded by the bacteria of decay. Since most municipal wastes in the United States are subjected to treatment which degrades organic waste to its inorganic products, in actual practice the fatty residue of soap wastes is degraded by bacterial action within the confines of a sewage treatment plant. What is then emitted to surface waters is only carbon dioxide and water. Hence, there is little or no impact on the aquatic ecosystem due to biological oxygen demand (which accompanies bacterial degradation of organic wastes) arising from soap wastes. Nor is the product of soap

degradation, carbon dioxide, usually an important ecological intrusion since it is in plentiful supply from other environmental sources, and in any case is an essential nutrient for photosynthetic algae. Hence, as compared with soap the production of synthetic detergents is a more serious source of pollution.

Once used and released into the environment in waste, detergents generate a more intense environmental impact than a comparable amount of soap. Soap is wholly degradable to carbon dioxide, which is usually rather innocuous in the environment. In contrast even the newer detergents which are regarded as degradable because the paraffin chain of the molecule (being unbranched, in contrast with the earlier non-degradable detergents) is broken down by bacterial action, nevertheless leave a residue of phenol which may not be degraded and may accumulate in surface waters. Phenol is a rather toxic substance, being foreign to the aquatic ecosystem.

Unlike soap, detergents are compounded with considerable amounts of phosphate in order to enhance their cleansing action and as a water softener. Phosphate may readily induce water pollution by stimulating heavy overgrowths of algae, which on dying release organic matter into the water and thus overburden the aqueous ecosystem. Figure 8 shows that nearly all of the increase in sewage phosphorus in the United States can be accounted for by the phosphorus content of detergents. Since soap, which has been displaced by detergents, is quite free of phosphate the environmental impact due to phosphate is clearly a consequence of the technological change in cleaner production.

The change in the environmental impact index of phosphate in cleaners between 1946 and 1968 is shown in Table V. In this period the overall environmental impact index increased 1845%. The increase in the effect of population size was 42%; the effect of per capita use of cleaners does not change; the technological factor, i. e., that due to the displacement of phosphate-free soap by detergents containing an average of about 4% phosphorus, increased about 1270%. The relative importance of this change in cleaner technology in intensifying environmental impact is quite evident.

#### 4) Secondary environmental effects of technological displacements

Increased production of synthetic organic chemicals leads to intensified environmental impacts in several different ways. This segment of industry has heavy power requirements; in contributing to increased power production the industry adds as well to the rising levels of air pollutants that are emitted by power plants. In addition organic synthesis releases into the environment a wide variety of reagents and intermediates,

which are foreign to natural ecosystems and often toxic, thus generating important, often poorly understood, environmental impacts. A common example are massive fish kills and plant damage resulting from release of organic wastes, insecticides and herbicides to surface waters or the air.

Perhaps the most serious environmental impact attributable to the increased production of synthetic organic chemicals is due to the intrusion of mercury into surface waters. This effect is mediated by chlorine production. This substance is a vital reagent in many organic synthesis; about 80% of present chlorine production finds its end use in the synthetic organic chemical industry. Moreover, a considerable proportion of chlorine production is carried out in electrolytic mercury cells; until recent control measures were imposed on the industry, about .2-.5 lbs. of mercury were released to the environment per ton of chlorine manufactured in mercury electrolytic cells. This means, for example, that the substitution of nylon for cotton has generated an intensified environmental impact due to mercury, for nylon production (unlike cotton production) involves the use of chlorinated intermediates, therefore of chlorine, and hence the release of mercury into the environment.

Similarly the displacement of steel and lumber by aluminum adds to the burden of air pollutants, for aluminum production is extremely power consumptive. Per pound of aluminum produced, about 29,860 BTU's of power are required to generate the necessary electricity whereas about 4,615 BTU's are used per pound of steel produced. Cement, which tends to displace steel in construction is also extremely power consumptive. The production of chemicals, aluminum and cement account for about 56% of the total industrial use of electricity in the United States.

##### 5) Packaging

The displacement of older forms of packaging by "disposable" containers, such as non-returnable bottles is another example of the intensification of environmental impact due to the postwar pattern of U.S. economic growth. This is illustrated in Fig. 10 and Table VI. Here it is evident that there has been a very striking increase in environmental impact due to beer bottles, which are not assimilated by ecological systems and are, in their manufacture, quite power consumptive. It is also evident that the major factor in this intensified environmental impact is the new technology--the use of non-returnable bottles to contain beer--rather than 'affluence' with respect to per capita consumption of beer, or increased population.

#### 6) Automotive Vehicles

Finally there is the problem of assessing the environmental impact of changes in patterns of passenger travel and freight traffic since 1946. Particularly important has been the increased use of automobiles, busses and trucks.

The environmental impact of the internal combustion engine is due to the emission of nitrogen oxides, carbon monoxide, waste fuel and lead. The intensities of these impacts, as measured by the levels of these pollutants in the environment is a function, not only of the vehicle-miles travelled, but also of the nature of the engine itself-- i. e., technological factors are relevant as well.

The technological changes in automotive engines since World War II have worsened environmental impact. These are illustrated in Fig. 11. Thus, for passenger automobiles, overall mileage per gallon of fuel declined from 14.97 in 1949 to 14.08 in 1967, largely because average horsepower increased from 100 to 240. Another important technological change was in average compression ratio, which increased from about 5.9 to 9.5 in 1946-68. This engineering change has had two important effects on the environmental impact of the gasoline engine. First increasing amounts of tetraethyl lead are needed as a gasoline additive in order to suppress the engine knock that occurs at high compression ratios. As shown in Fig. 12, annual use of tetraethyl lead has increased significantly in 1946-68. Essentially all of this lead is emitted from the engine exhaust and is disseminated into the environment. Since lead is not a functional element in any biological organism, and is in fact toxic, it represents an external intrusion on the ecosystem and generates an appreciable environmental effect.

A second consequence of the increase in engine compression ratio has been a rise in the concentration of nitrogen oxides emitted in engine exhaust. This has occurred because the engine temperature increases with compression ratio. The combination of nitrogen and oxygen, present in the air taken into the engine cylinder, to form nitrogen oxides is enhanced at elevated temperatures. Nitrogen oxide is the key ingredient in the formation of photochemical smog. Through a series of light-activated reactions, involving waste fuel, nitrogen oxides induce the formation of peroxyacetyl nitrate, the noxious ingredient of photochemical smog. Smog of this type was first detected in Los Angeles in 1942-3; it was unknown in most other United States cities until the late 1950's and 1960's, but is now a nearly universal urban pollutant. Peroxyacetyl nitrate is a toxic agent, to man, agricultural crops and trees. Introduction of this agent has probably increased by about an order of magnitude in 1946-68.

The Environmental Impact Indices for nitrogen oxides and lead are shown in Tables VII and VIII respectively. The total environmental impact for nitrogen oxides increased by about 630% between 1946 and 1967. The technological factor (the amount of nitrogen oxides emitted per vehicle-mile) increased by 158%, vehicle-miles travelled per capita increased by about 100%, and the population factor by about 41%. In the case of tetraethyl lead, the largest increase in impact is in vehicle-miles travelled per capita (100%), followed by the technological factor (83%) and the population factor (41%). It is evident that the major influences on automotive air pollution are increased per capita mileage (in part because of changes in work-residence distribution due to the expansion of suburbs) and the increased environmental impact per mile travelled due to technological changes in the gasoline engine.

A similar situation obtains with respect to overland shipments of inter-city freight. Here truck freight has tended to displace railroad freight. And again the displacing technology has a more severe environmental impact than does the displaced technology. This is evident from the energy required to transport freight by rail and truck: 624 BTU/ton-mile by rail and 3462 BTU/ton-mile by truck. It should be noted as well that the steel and cement required to produce equal lengths of railroad and expressway (suitable for heavy truck traffic) differ in the amount of power required in the ratio 1 to 3.6. This is due to the rather power-consuming nature of cement production and to the fact that four highway lanes are required to accommodate heavy truck traffic. In addition, the divided roadway requires a 400 foot right-of-way while a train roadbed needs only 100 feet. In all these ways the displacement of railroads by automotive vehicles, not only for freight, but also for passenger travel, has intensified the resultant environmental impact.

### Some Conclusions

The data presented above reveal a functional connection between economic growth--at least in the United States since 1946--and environmental impact. It is significant that the range of increase in the computed environmental impacts agrees fairly well with the independent measure of the actual levels of pollutants occurring in the environment. Thus, the increase in environmental impact index for tetraethyl lead computed from gasoline consumption data for 1946-67 is about 400%; a similar increase in environmental lead levels has been recorded from analyses of layered ice in glaciers. Similarly, the 648% increase in the 19-year period 1949-68 in the environmental impact index computed for nitrogen fertilizer is in keeping with the few available large-scale field measurements. Thus, field data show that nitrate entering the Missouri River

as it traversed Nebraska in the 6-year period 1956-62 increased a little over 200%.<sup>8</sup> The environmental impact indices computed for several aspects of automotive vehicle use are also in keeping with general field observations. It is widely recognized that the most striking increase among the several aspects of environmental deterioration due to automotive vehicles, has occurred with respect to photochemical smog. This pollutant was detected for the first time in Los Angeles in 1942-43.

Since then it has increased, nationally, by probably an order of magnitude, appearing in nearly every major city and even in smaller ones in the last 5 years. However, in the period 1946-68 total use of automotive vehicles, as measured by gasoline consumption, increased by only about 200%--an increment too small to account for the concurrent rise in the incidence of photochemical smog. It is significant, then, that this disparity between the observed increase in smog levels and the increase in vehicle use is accounted for by the environmental impact index computed for nitrogen oxides, the agent which initiates the smog reaction, for that index increased by 630% in 1946-67.

These agreements with actual field data support the conclusion that the computations represented by the environmental impact index provide a useful approximation of the changes in environmental impact associated with the relevant features of the growth of the United States economy since 1946. In particular, we can therefore place some reliance on the subdivision of the total impact index into the several factors: population size, per capita production or consumption and the technology of production and use.

It is of interest to make a direct comparison of the relative contributions of increases in population size and in "affluence," and of changes in the technology of production, to the increases in total environmental impact which have occurred since 1946. The ratio of the most recent total index value to the value of the 1946 index (or to the value for the earliest year for which the necessary data are available) is indicative of the change in the total impact over this period of time. The relative contributions of the several factors to these total changes is then given by the ratios of their respective partial indices. Figure 13 reports such comparisons for the 6 productive activities evaluated. The population factor contributes only between 12 and 20% of the total changes in impact index. For all but the automotive pollutants, the "affluence" factor makes a rather small contribution--no more than 5%--to the total changes in impact index. For nitrogen oxides and tetraethyl lead (from automotive sources), this factor accounts for about 40% of the total effect, reflecting a considerable increase in the number of vehicle-miles travelled per capita since 1946. The technological changes in the processes which generate the various economic goods, contribute from 40-90% of the total increases in impact.

In evaluating these results it should be noted that automotive travel is itself strongly affected by a kind of technological transformation: the rapid increase of suburban residences in the United States and the concomitant failure to provide adequate railroad and other mass transportation to accommodate to this change. That the overall increase in vehicle-miles travelled per capita since 1946 (about 100%) is related to increased residence-work travel incident upon this change is suggested by the results of a 1963 survey. It was found that 90% of all automobile trips, representing 30% of total mileage travelled, are 10 miles or less in length. The mean residence-work travel distance was about 5.5 miles. Thus, it is probably appropriate to regard the increase in per capita vehicle-miles travelled by automobile as not totally attributable to increased "affluence," but rather as a response to new work-residence relationships which are costly in transportation.

During the period from 1946 to the present, pollution levels in the United States have increased sharply--generally by an order of magnitude or so. It seems evident from the data presented above that most of this increase is due to one of the three factors that influence environmental impact--the technology of production--and that both population growth and increase in "affluence" exert a much smaller influence. Thus the chief reason for the sharp increase in environmental stress in the United States is the sweeping transformation in production technology in the post-war period. Productive activities with intense environmental impacts have displaced activities with less serious environmental impacts; the growth pattern has been counter-ecological.

The foregoing conclusion is easily misconstrued to mean that technology is therefore, per se, ecologically harmful. That this interpretation is unwarranted can be seen from the following examples.

Consider the following simple transformation of the present, ecologically-faulty, relationship among soil, agricultural crops, the human population and sewage. Suppose that the sewage, instead of being introduced into surface waters as it is now, whether directly or following treatment, is instead transported from urban collection systems by pipeline to agricultural areas, where--after appropriate sterilization procedures--it is incorporated into the soil. Such a pipeline would literally reincorporate the urban population into the soil's ecological cycle,

restoring the integrity of that cycle, and incidentally removing the need for inorganic nitrogen fertilizer--which also stresses the aquatic cycle. Hence the urban population is then no longer external to the soil cycle and is therefore incapable either of generating a negative biological stress upon it or of exerting a positive ecological stress on the aquatic ecosystem. But note that this state of zero environmental impact is not achieved by a return to 'primitive' conditions, but by an actual technological advance, the construction of a sewage pipeline system.

Or consider the example provided by the technological treatment of gold and other precious metals. Gold is, after all, subject to numerous technological manipulations, which generate a series of considerable economic values. Yet we manage to accomplish all of this without intruding more than a rather small fraction of all the gold ever acquired by human beings into the ecosphere. Because we value it so highly very little gold is "lost" to the environment. In contrast, most of the mercury which has entered commerce in the last generation has been disseminated into the environment, with very unfortunate effects on the environment. Clearly, given adequate technology--and motivation--we could be as thrifty in our handling of mercury as we are of gold, thereby preventing the entry of this toxic material into the environment. Again what is required is not necessarily the abandonment of mercury-based technology, but rather the improvement of that technology to the point of satisfactory compatibility with the ecosystem.

Generally speaking then, it would appear possible to reduce the environmental impact of human activities by developing alternatives to ecologically-faulty activities. This can be accomplished, not by abandoning technology and the economic goods which it can yield, but by developing new technologies which incorporate not only the knowledge of the physical sciences (as most do moderately well; the new machines do, after all, usually produce their intended goods), but ecological wisdom as well.

The foregoing considerations show that the deterioration of the environment, whatever its cost in money, social distress and personal suffering, is chiefly the result of the ecologically-faulty technology which has been employed to remake productive enterprises. The resulting environmental impacts stress the basic ecosystems which support the life of human beings, destroy the "biological capital" which is essential to the operation of industry and agriculture, and may, if unchecked, lead to the catastrophic collapse of these systems. The environmental impacts already generated are sufficient to threaten the continued development of the economic system--witness the current difficulties

in the United States in siting new power plants at a time of severe power shortage, the recent curtailment of industrial innovation in the fields of detergents, chemical manufacturing, insecticides, herbicides, chlorine production, oil drilling, oil transport, supersonic aviation, nuclear power generation, industrial uses of nuclear explosives, all resulting from public rejection of the concomittant environmental deterioration.

It seems probable, if we are to survive economically as well as biologically, that much of the technological transformation of the industrialized economy since 1946 will need to be, so to speak, redone in order to bring productive technology much more closely into harmony with the inescapable demands of the ecosystem. This will require the development of massive new technologies including: systems to return sewage and garbage directly to the soil; the replacement of synthetic materials by natural ones; the reversal of the present trend to retire soil from agriculture and to elevate the yield per acre; the development of land transport that operates with maximal fuel efficiency at low combustion temperatures and with minimal land-use; the sharp curtailment of the use of biologically active synthetic organic agents. In effect what is required is a new period of technological transformation of the economy, which reverses the counter-ecological trends developed since 1946. We might estimate the cost of the new transformation, from the cost of the former one, which in the United States must represent a capital investment in the range of hundreds of billions of dollars. To this must be added, of course, the cost of repairing the ecological damage which has already been incurred, such as the eutrophication of Lake Erie, again a cost to be reckoned in the hundreds of billions of dollars.

What might all this cost? Some very rough but useful approximations can be made. For example, it is generally reckoned that the total stock of capital equipment in the United States is about three times the annual GNP, or about two thousand four hundred billion dollars at the present time. (This and all following numbers are expressed as 1958 dollars to compensate for inflation.) A very rough estimate of the existing capital equipment that would need to be replaced in order to remedy major ecological faults might be about one-fourth, or about six hundred billion dollars worth. In comparison, the expenditures for structures and producers' durable equipment by private investors during the period 1946 to 1968 when, as we have seen, most of the ecologically faulty enterprises were built, amounts to roughly one thousand billion dollars. Accordingly, on the basis of the first estimates, something like one half of the postwar productive enterprises would need to be replaced by ecologically sounder ones.

Rough as they are, these figures give us some sense of the magnitude of the task of ecological reconstruction of the national productive system. To this estimate must be added the costs of efforts to restore damaged sectors of the ecosystem, which would range in the area of hundreds of billion dollars. This cost need not, and of course cannot, be met at once. If we accept as the period of grace--the time available before serious large-scale ecological catastrophes overtake us--let us say twenty-five years, then the cost of survival becomes about forty billion dollars annually over that period of time (again in 1958 dollars). Perhaps the simplest way to summarize all this is that most of the nation's resources for capital investment would need to be engaged in the task of ecological reconstruction for at least a generation. This means that new investments in agricultural and industrial production and in transportation would need to be governed chiefly by ecological considerations, so that the over-all pattern of investment would have to come under the guidance of ecological rather than conventional economic imperatives.

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TABLE I

## POST-WAR INCREASES IN POLLUTANT EMISSIONS

Pollutant	Annual Production		Year	Amount	Percent Increase over indicated period
	Year	Amount			
Inorganic Fertilizer Nitrogen	1949	.91x10 <sup>6</sup> tons	1968	6.8x10 <sup>6</sup> tons	648
Synthetic Organic Pesticides	1950	286x10 <sup>6</sup> lbs.	1967	1050x10 <sup>6</sup> lbs.	267
Detergent Phosphorus	1946	11x10 <sup>6</sup> lbs.	1968	214x10 <sup>6</sup> lbs.	1,845
Tetraethyl Lead**	1946	.048x10 <sup>6</sup> tons	1967	.25x10 <sup>6</sup> tons	415
Nitrogen Oxides**	1946	10.6*	1947	77.5*	630
Beer Bottles	1950	6.5x10 <sup>6</sup> gross	1967	45.5x10 <sup>6</sup> gross	595

\* Dimension = NO<sub>x</sub> (ppm) x gasoline consumption (gals x 10<sup>-6</sup>); estimated from product of passenger vehicle gasoline consumption and ppm of NO<sub>x</sub> emitted by engines of average compression ratio 5.9 (1946) and 9.5 (1967) under running conditions, at 15 in. manifold pressure. NO<sub>x</sub> emitted: 500 ppm in 1946; 1200 ppm in 1967 (Ref.)

\*\* Automotive emissions

TABLE II  
FERTILIZER NITROGEN

## ENVIRONMENTAL IMPACT INDEX

	<u>Index Factors</u>			Total Index
	(a)	(b)	(c)	
	Population (1000's)	<u>Crop Production</u> Population (Prod. units/cap.)	<u>Fertilizer Nitrogen</u> Crop Production (tons/prod. unit)	Fertilizer Nitrogen (1000's of tons)
1949	149,304	$5.43 \times 10^{-7}$	11,284*	914
1968	199,846	$6.00 \times 10^{-7}$	57,008	6841
1968:1949	1.34	1.11	5.05	7.48
% Increase	34	11	405	648

\* The crop output index is an indicator of agricultural productivity with the 1957-1959 average = 100.

TABLE III

## SYNTHETIC ORGANIC PESTICIDES

	<u>Index Factors</u>			<u>Total Index</u>
	(a)	(b)	(c)	(a x b x c)
	Population (1000's)	<u>Crop Production</u> Population (Crop Production Units/cap.)	<u>Pesticide Consumption</u> Crop Production (1000 lbs./Prod. Unit)	Synthetic Organic Pesticides (Million lbs.)
1950	151,868	$5.66 \times 10^{-7}$	3326	286
1967	197,859	$5.96 \times 10^{-7}$	8898	1050
1967:1950	1.30	1.05	2.68	3.67
% Increase 1967:1950	30	5	168	267

TABLE IV  
 COTTON AND NYLON:  
 ENVIRONMENTAL CHARACTERISTICS

	Cotton	Nylon	Comparative Environmental Impact
Raw Materials	CO <sub>2</sub> , H <sub>2</sub> O	Petroleum	Cotton, renewable Nylon, non-renewable
Process	CO <sub>2</sub> + H <sub>2</sub> O light → glucose → cellulose (ca 70-90°F.)  cultivation, ginning, spinning, require power	Petroleum (distill) → Benzene (550°F.) →  Cyclohexane (300°F.) → Cyclohexano (200-400°F.) → Adipic acid (600-700°F.) → Adiponitrile (200-250°F.) →  Hexamethylene diamine → Nylon 610  Distillation and other purification at most of above steps; power required to operate process	Fuel combustion and resultant air pollution:  probably Nylon } Cotton
Product	Cellulose	Polyamide	Cellulose wholly biodegradable, Polyamide not degradable

TABLE V  
 DETERGENT PHOSPHORUS  
 ENVIRONMENTAL IMPACT INDEX

	<u>Index Factors</u>			<u>Total Impact</u>
	(a)	(b)	(c)	(a x b x c)
	<u>Population</u> (1000's)	<u>Cleaners*</u> <u>Population</u> (lbs/cap)	<u>Phosphorus</u> <u>Cleaners</u> (lbs/ton of cleaner)	<u>Phosphorus from</u> <u>Detergents**</u> (10 <sup>6</sup> lbs)
1946	140,686	22.66	6.90	11
1968	194,846	15.99	137.34	214
1968:1946	1.42	0.69 (1.00)***	19.90 (13.70)	19.45
% increase 1946-1968	42	(0)	(1,270)	1,845

\* Assuming that 35% of detergent weight is active agent.

\*\* Assuming average phosphorus content of detergents = 4%.

\*\*\* Because of uncertainties regarding the content of active agent in detergents, especially soon after their introduction, the apparent reduction in per capita use of cleaners is not regarded as significant; the numbers contained in parentheses are based on the assumption that this value does not change significantly.

TABLE VI  
BEER BOTTLES  
ENVIRONMENTAL IMPACT INDEX

	<u>Index Factors</u>			<u>Total Index</u>
	(a)	(b)	(c)	(a x b x c)
	Population (1000's)	<u>Beer Consumption</u> Population (Gallons/cap)	<u>Beer Bottles</u> Beer Consumption (Bottles/gallon)	Beer Bottles (1000 Gross)
1950	151,868	24.99	.25	6,540
1967	197,859	26.27	1.26	45,476
1967:1950	1.30	1.05	5.08	6.95
% Increase 1950-1967	30	5	408	595

TABLE VII  
 NITROGEN OXIDES  
 (Passenger Vehicles)  
 ENVIRONMENTAL IMPACT INDEX

	<u>Index Factors</u>			<u>Total Index</u>
	(a)	(b)	(c)	
	Population (1000's)	<u>Vehicle-Miles</u> Population	<u>Nitrogen Oxides*</u> Vehicle-miles	Nitrogen Oxides*
1946	140,686	1982	33.5	10.6
1967	197,849	3962	86.4	77.5
1967:1946	1.41	2.00	2.58	7.3
% Increase	41	100	158	630

\* Dimension=  $\text{NO}_x$  (ppm) x gasoline consumption (gals. x  $10^{-6}$ )  
 Estimated from product of passenger vehicle gasoline consumption and ppm of  $\text{NO}_x$  emitted by engines of average compression ratio 5.9 (1946) and 9.5 (1967) under running conditions, at 15 in. manifold pressure: 1946, 500 ppm  $\text{NO}_x$ ; 1967, 1200 ppm (Data from Ref. )

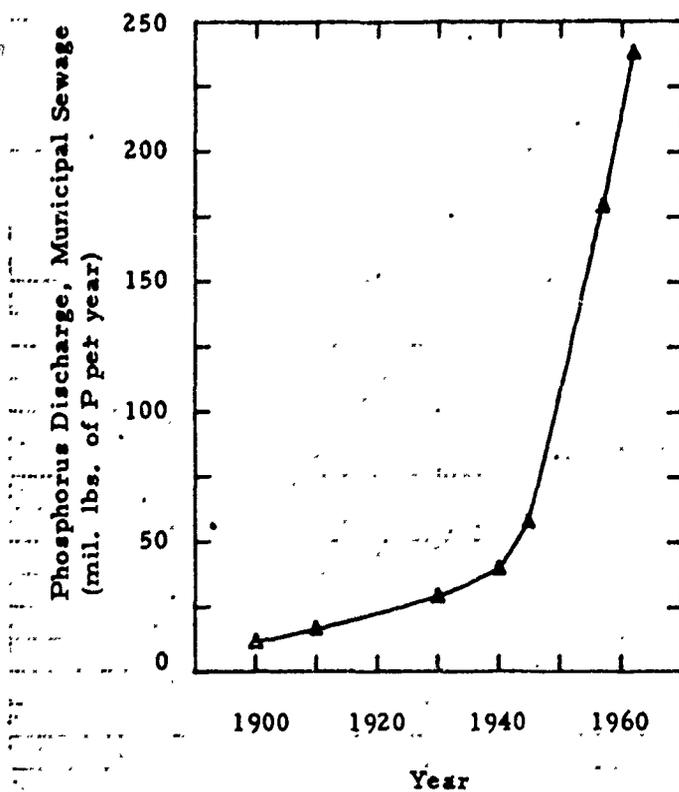
TABLE VIII  
TETRAETHYL LEAD  
ENVIRONMENTAL IMPACT INDEX

	<u>Index Factors</u>			<u>Total Index</u>
	(a)	(b)	(c)	Tetraethyl Lead** (1000's of tons)
	Population (1000's)	<u>Vehicle-Miles*</u> <u>Population</u> (veh. mi. /cap)	<u>Tetraethyl Lead**</u> <u>Vehicle-miles*</u> (lbs/million veh. mi.)	
1946	140,686	1984***	300***	48***
1967	197,859	3962	630	247
1967:1946	1.41	2.00	1.83	5.15
% Increase	41	100	83	415

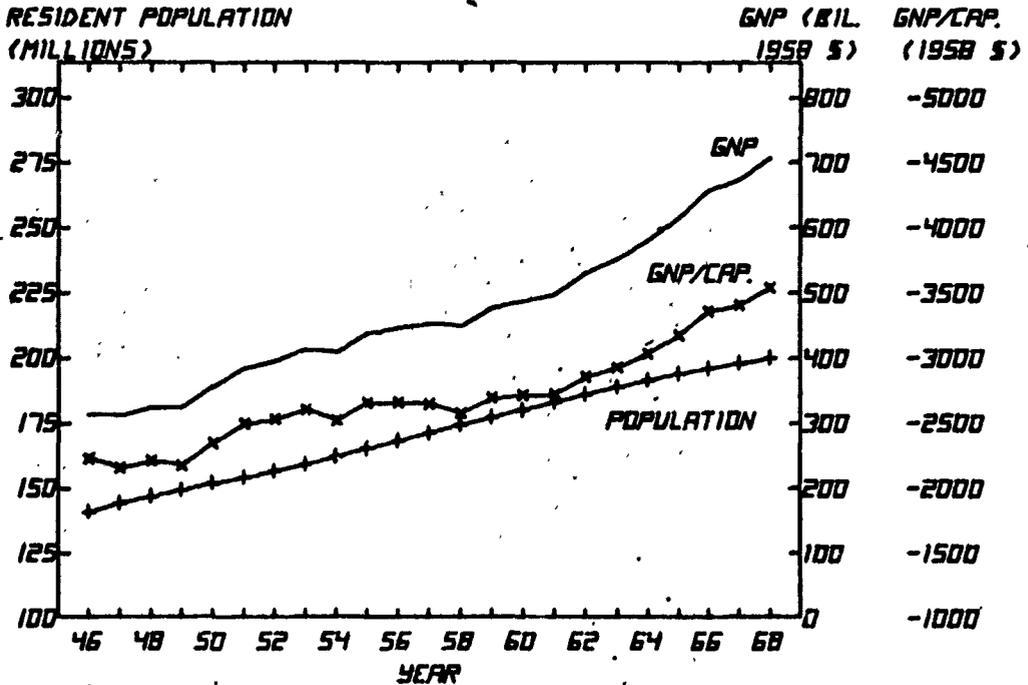
\* Passenger vehicles only.

\*\* Weight refers to lead content

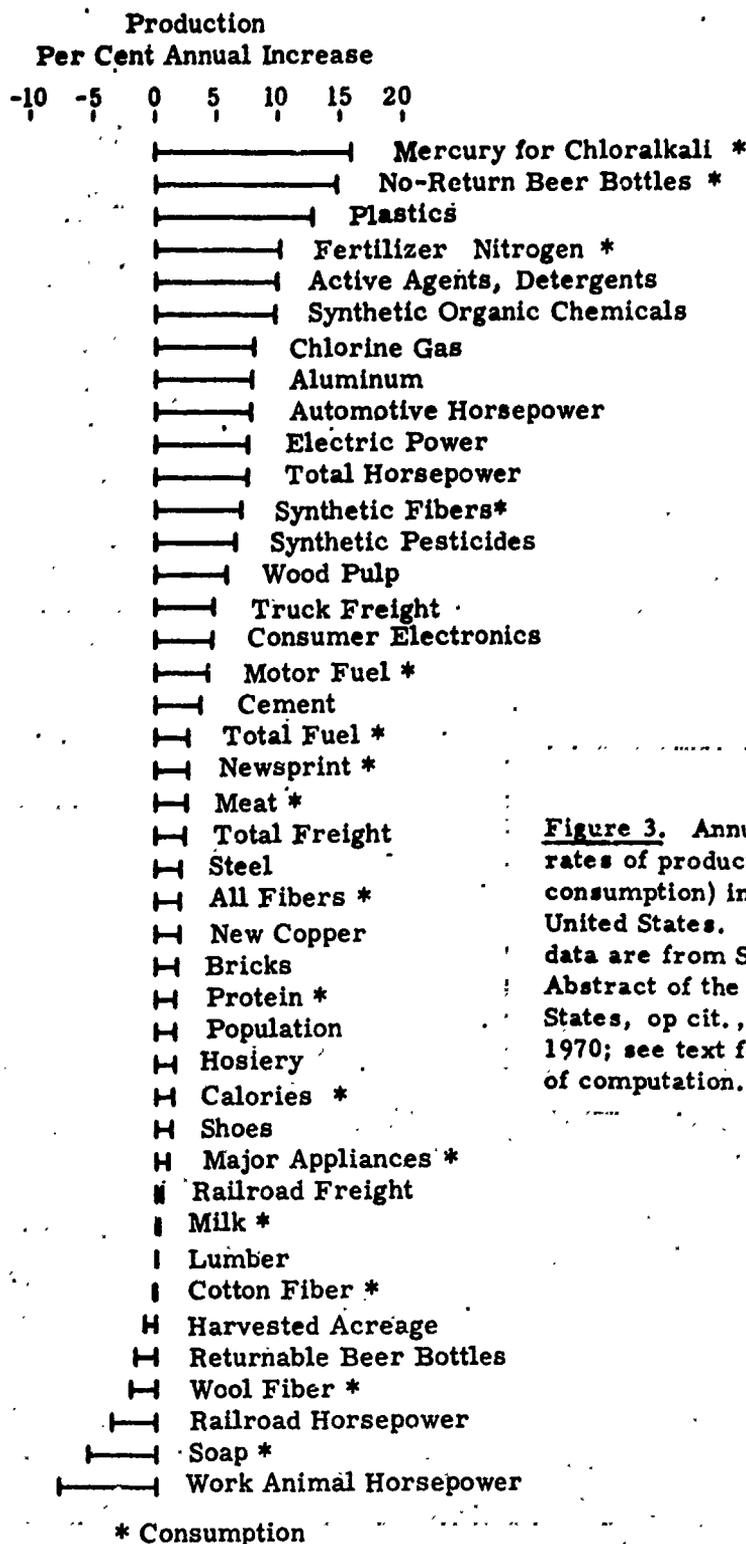
\*\*\* See note for Table IX



**Figure 1.** Phosphorus emitted by United States municipal sewage. Data are from Weinberger, L. W., et al. in Hearings before the Subcommittee on Science, Research and Development of the House Committee on Science and Astronautics, The Adequacy of Technology for Pollution Abatement, Vol. II, U.S. Government Printing Office, Washington, D. C., p. 756.



**Figure 2.** Changes in population, Gross National Product (reduced to 1958 dollars) and GNP per capita for the United States since 1946: Data are from Department of Commerce, Statistical Abstract of the United States, U.S. Government Printing Office, Washington, D.C., 1970, p. 5 and Department of Commerce, The National Income and Product Accounts of the United States 1929-1965, U.S. Government Printing Office, Washington, D.C., 1966, pp. 4-5.



**Figure 3.** Annual growth rates of production (or consumption) in the United States. Annual data are from Statistical Abstract of the United States, op cit., 1948-1970; see text for method of computation.

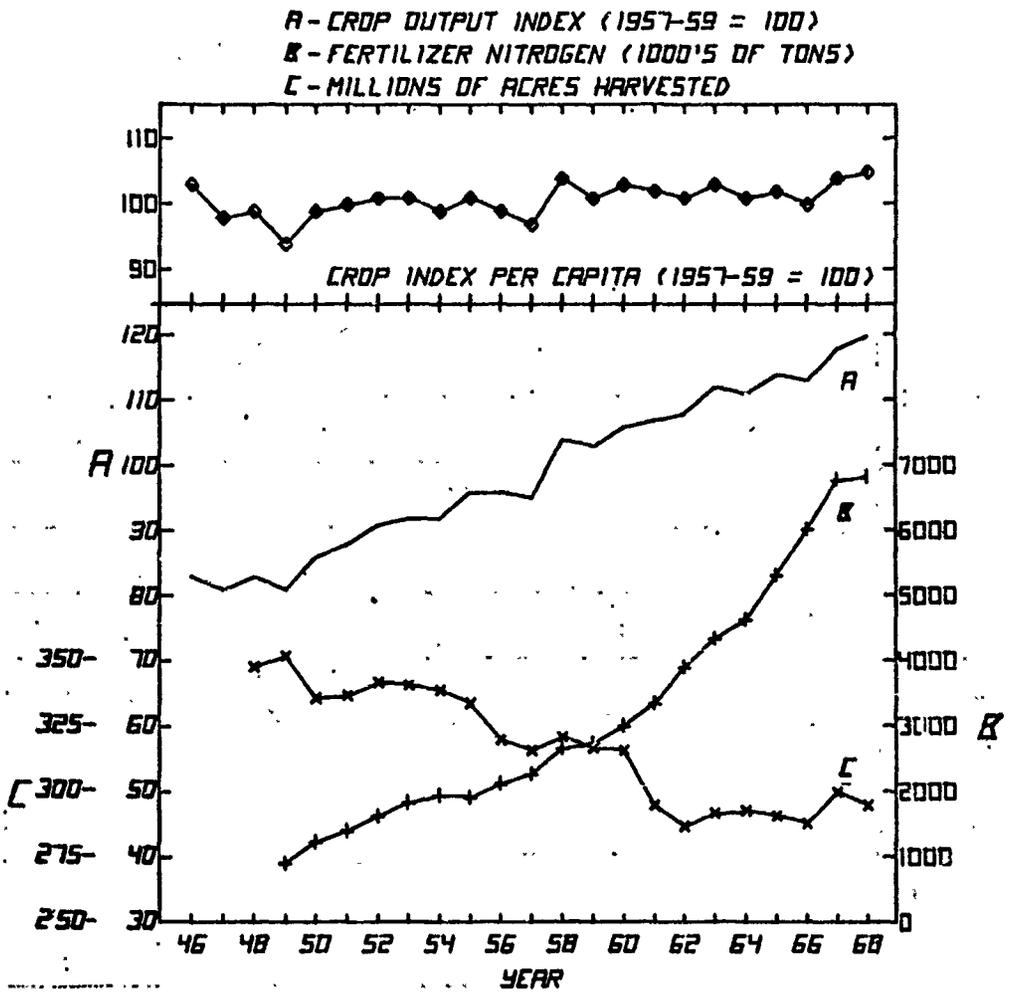
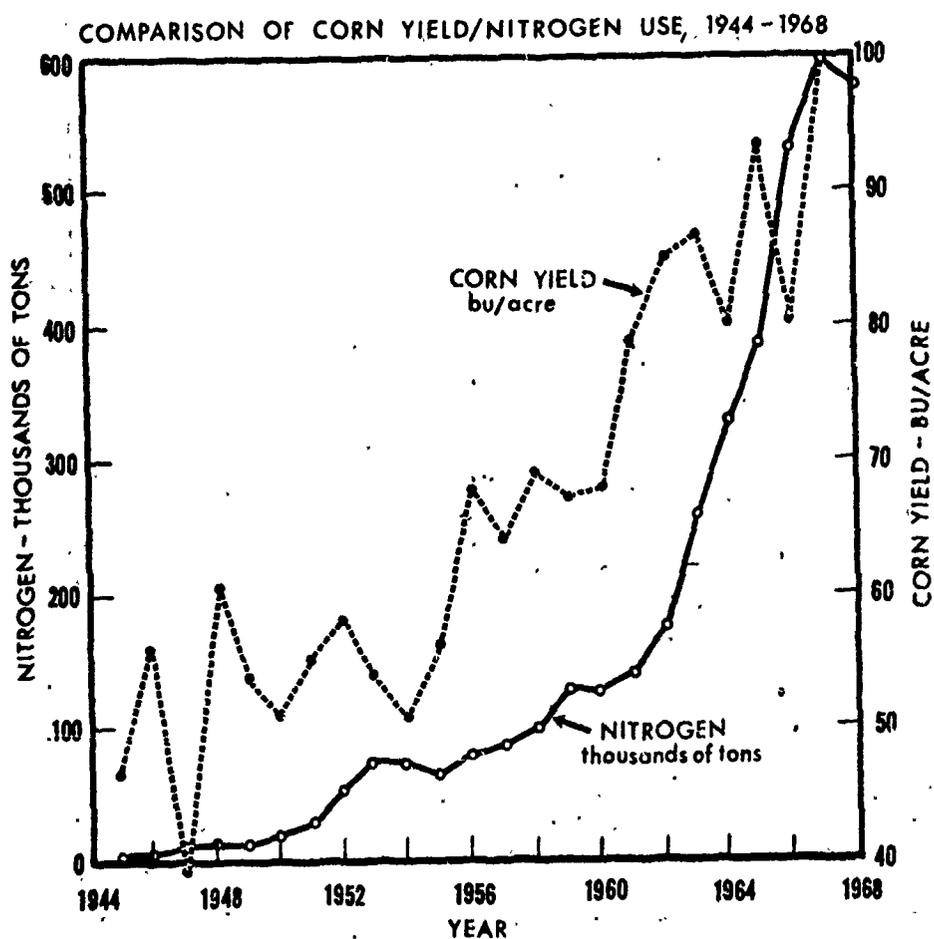


Figure 4. Changes in total crop output (as determined by U.S.D.A. Crop Index); in crop output per capita, in harvested acreage and in annual use of inorganic nitrogen fertilizer in the United States since 1946. Data are from *Agricultural Statistics*, U.S. Government Printing Office, Washington, D.C., 1967, pp. 531, 544, 583; 1970, pp. 444, 454, 481.



**Figure 5.** Corn yield and nitrogen usage for the State of Illinois. Data are from Dawes, J. H., et al. Proc. 24th Ann. Meeting Soil Conservation Society of America, Fort Collins, Colo., 1968.

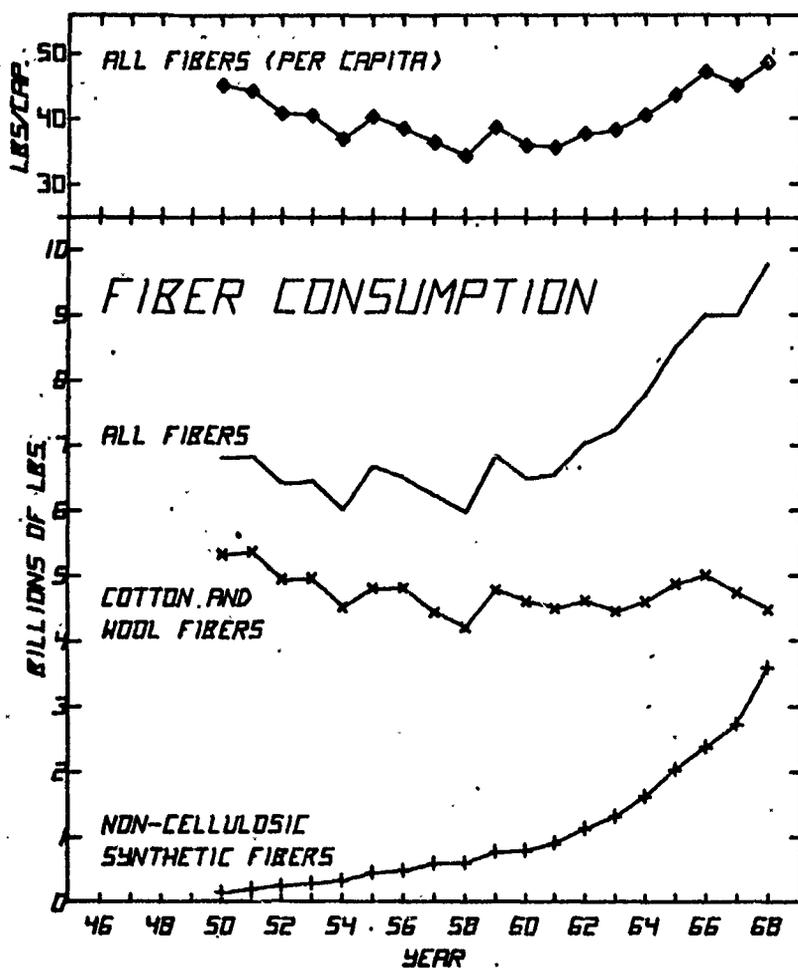


Figure 6. Natural and synthetic fiber production in the United States since 1946. Data are from Statistical Abstract of the United States, op cit., 1962, p. 198; 1966, p. 789; 1970, p. 713.

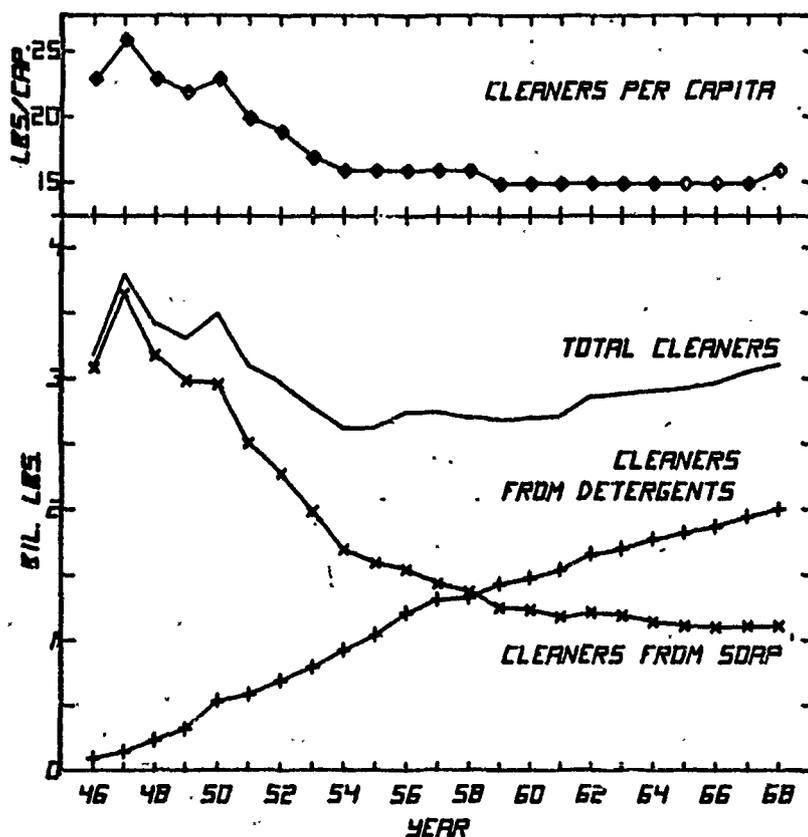
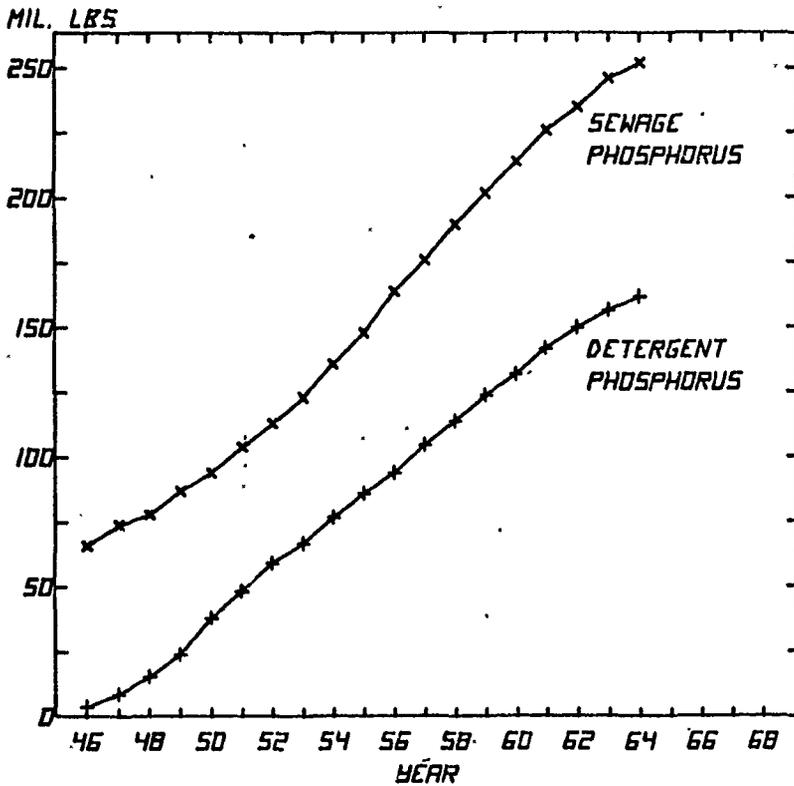
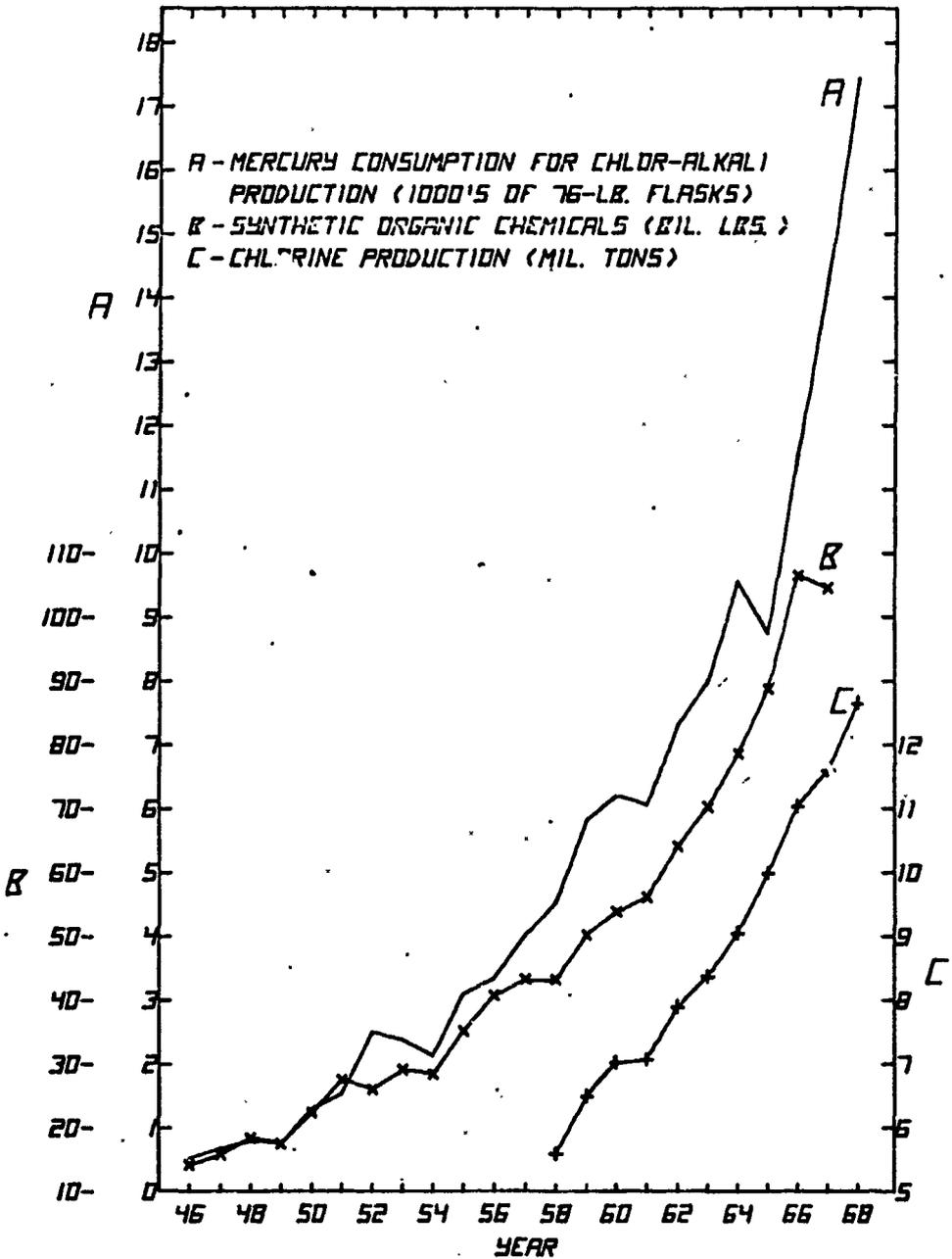


Figure 7. Total soap and detergent production and per capita consumption of total cleaners (soap plus detergent) in the United States since 1946. Data are from Agricultural Statistics, U.S. Government Printing Office, Washington, D.C., 1970, p. 149. Detergent data represent actual content of surface-active agent, which is estimated at about 37.5% of the total weight of the marketed detergent.



**Figure 8.** Concurrent values of phosphorus output from municipal sewage in the United States and phosphorus content of detergents produced. Former values are from Weinberger, L. W., *et al.* (see Legend, Figure 1). Detergent data are based on detergent production (see Legend, Figure 7) assuming an average of 4% P in marketed detergents.



**Figure 9.** Changes in annual production of synthetic organic compounds and of chlorine gas, and consumption of mercury for chlorine gas production in the United States since 1946. Data are from Bureau of the Census, Current Industrial Reports, Series M28A Inorganic Chemicals and Gases and from Statistical Abstract of the United States, op cit.

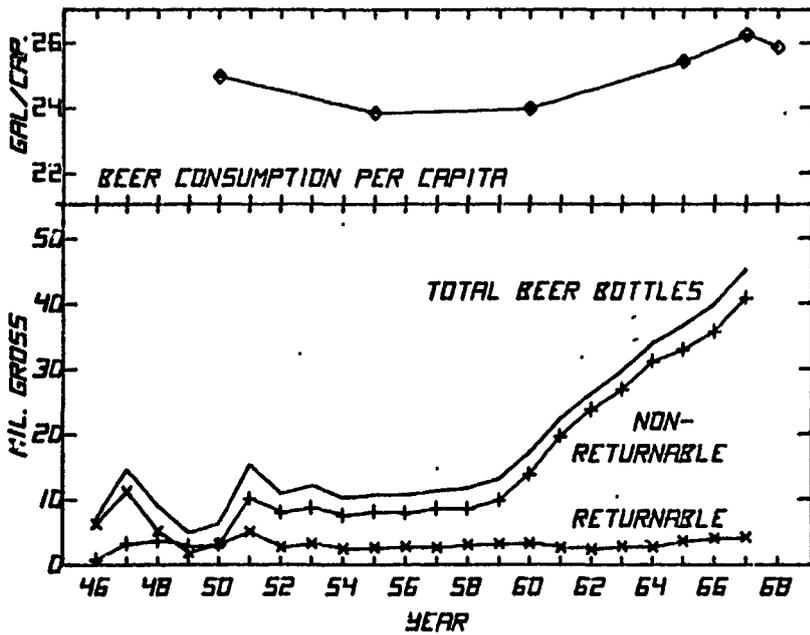


Figure 10. Per capita consumption of beer and production of beer bottles in the United States. Data are from *Statistical Abstract of the United States*, op cit., 1951, p. 792; 1955, p. 833; 1970, p. 12.

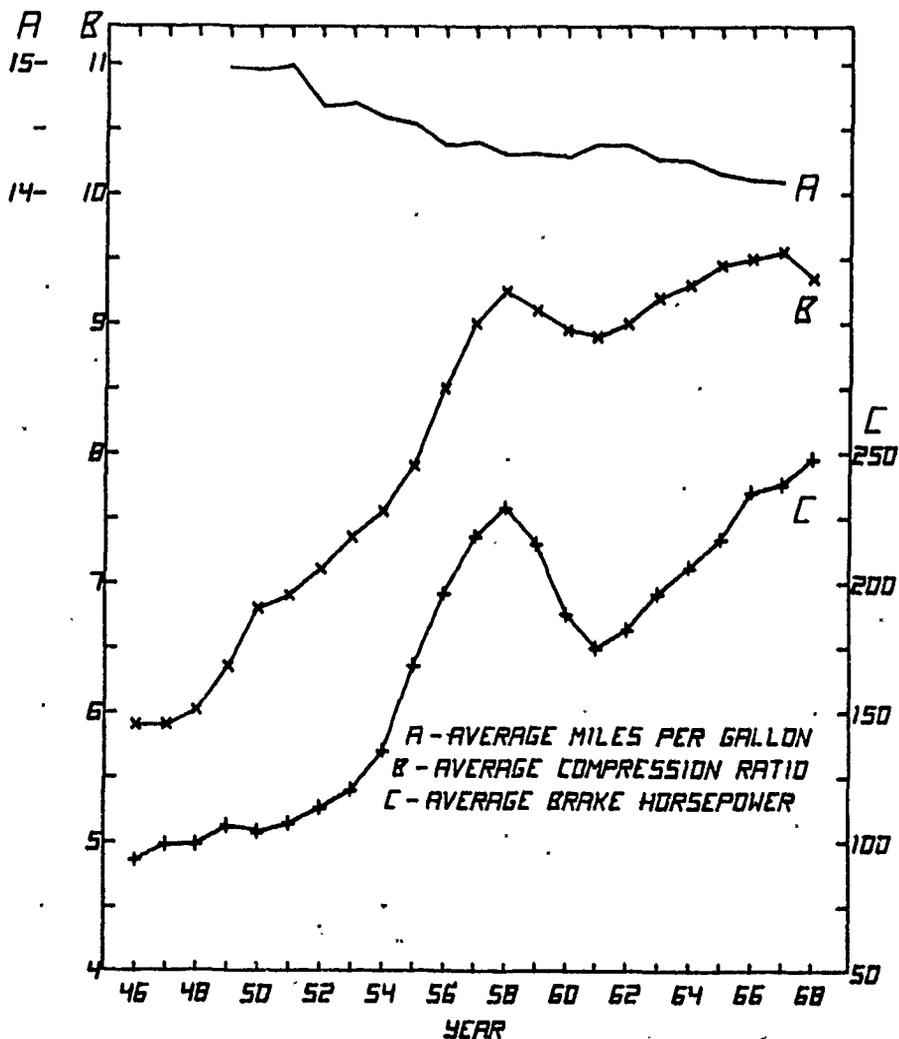


Figure 11. Average characteristics of passenger car engines produced in the United States since 1946. Brake horsepower and compression ratio data are from the 1951 and 1970 volumes of "Brief Passenger Car Data," Ethyl Corporation. Gasoline consumption data are from Statistical Abstract of the United States, op cit.

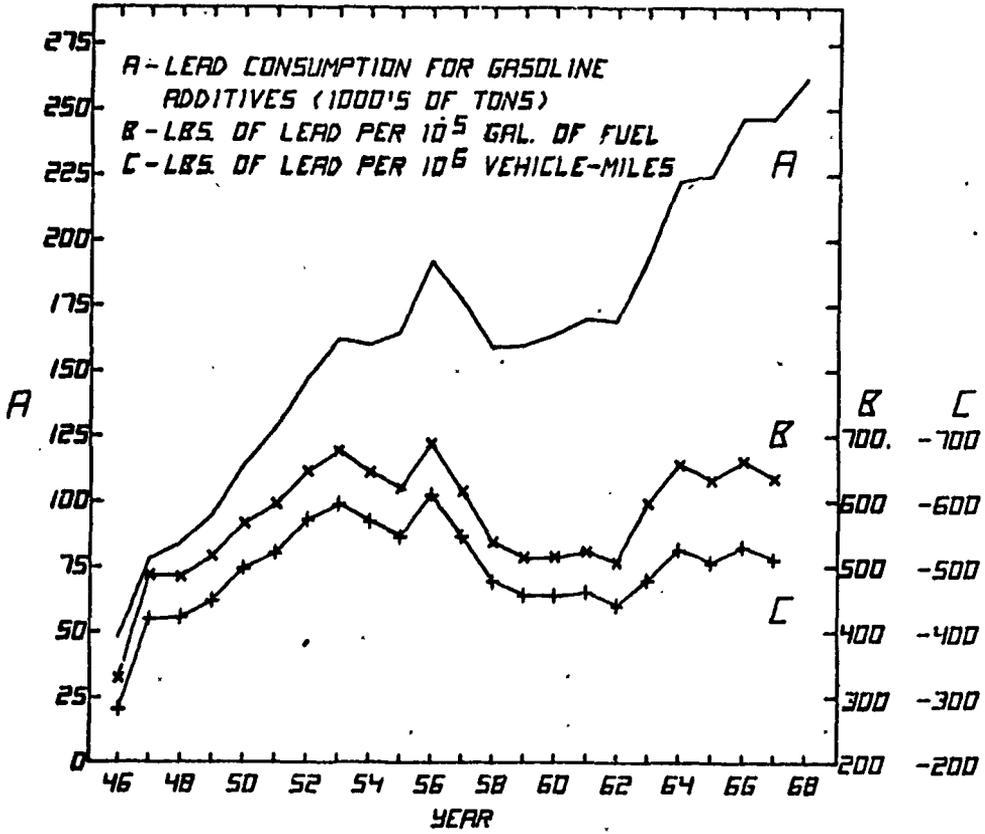


Figure 12. Lead emissions, from tetraethyl lead in gasoline, in the United States since 1946. Data are from Minerals Yearbook 1947-1968 and Statistical Abstract of the United States, op cit., (see Legend, Figure 10).

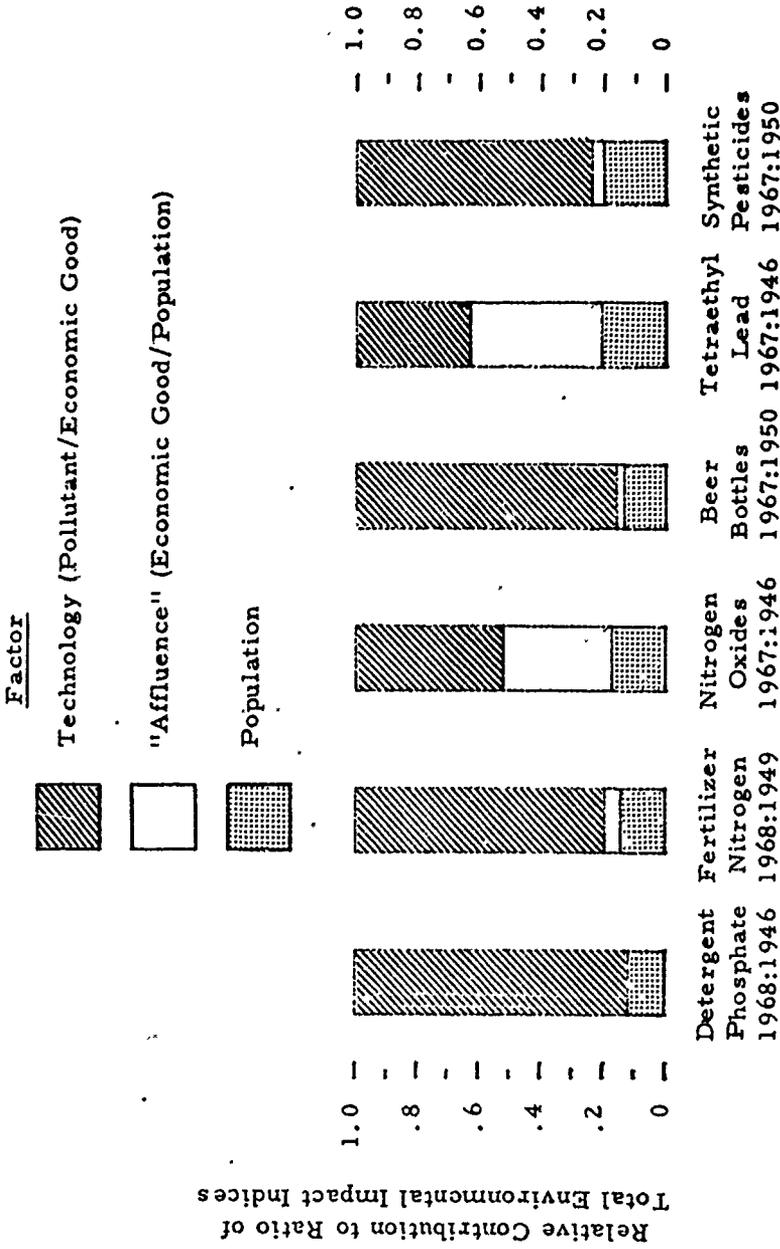


Figure 13. Relative contributions of several factors to changes in environmental impact indices. The contributions of population size, "affluence" (production per capita), and technological characteristics (amount of pollutant released per unit production) to the total environmental impact indices were computed as shown in the text. Each bar is subdivided to show the relative contributions, on a scale of 1.0, of the several factors to the ratio of the total impact index value for the later year to the value for the earlier year.

Senator HOLLINGS. We want to welcome Mr. Hugh Downs. He is a great listener; he has learned what we would all like to learn, and that is how to listen.

We are delighted to have you, Mr. Downs. We welcome you to the Committee and we will be glad to hear from you at this time.

### STATEMENT OF HUGH DOWNS

Mr. Downs. Thank you, Mr. Chairman. Previous witnesses in this and other sessions have stressed the pollution peril to our oceans, the life in the oceans, and the importance of that ocean to us. It has been generally agreed that steps for a pretty immediate remedy must be taken, and some sort of education process can be vitally helpful in creating an informed public which will back its legislators in the boldness now called for.

It is quite human to cling to conditions as we imagine them to be, even when the conditions no longer exist. In Marie Antoinette's mind the monarchy was safe enough for her to say, "Let them eat cake," while the very sound of the sharpening of the guillotine was in her ears.

How many of you have seen grown-up human beings during an electric power failure, while groping in the dark for a candle, flick a light switch so that they could see better to locate the candle? And not once, but repeatedly! We just can't quite believe that we aren't going to get light when we hit that switch!

In the same way, we can't deep down believe that pollution will really harm us! Doesn't the wind always blow smoke away? Don't we flush away sewage? Don't we throw out garbage? Sewage and garbage and some smoke break down into elements or simple compounds and can be recycled, but sometimes we use and the "throw out" special pollutants—pollutants with long, virulent life which chemists tell us not only resist breaking down and recycling, but tend to concentrate in living organisms doing damage to whole life chains—whole ecosystems. When we use DDT we can't throw it out because wherever we leave it, it washes into the sea.

We need to realign our thinking to realize we can't really throw out anything on earth, we can only move it around. The first thing that really were ever thrown out in the history of the world were the things left on the moon by astronauts. All other trash from the beginning of time has been moved around, but not thrown out.

Shortly after Lewis and Clark crossed the continent at the beginning of the 19th Century, trappers supplying beaver to the men's hat industry must have felt that the supply of beaver was inexhaustible. But before the Civil War the beaver was in danger of extinction. It took laws to protect that animal.

Vastness is often overwhelming and humbling but it can also be a comforter, and I think there is a danger in the comfort vastness offers. When you look at the size of this country, particularly in the areas west of the Mississippi, you have to forgive those who believed during the first half of the 19th century that the supply of everything—pelts, forests, water, air, buffalo—was endless. Even today threats to land resources, air and water are not highly visible, except in areas of concentrated pollution. We are tempted to think that the oceans in their vastness are virtually immune to pollution by man. This is deceptive,

as we have heard this morning, in the same way that the imagined invulnerability of the beaver was deceptive.

There are 330 million cubic miles of water in the world's oceans. All of the organic garbage man has ever produced could be distributed through the oceans today, and their ability to recycle organic material would not be strained. What the experts are trying to impress on us is that it is not quantity but the nature of some of man's pollutants and where they go that is threatening the very life of the ocean and with it human life. It is through its life that the ocean returns oxygen to the atmosphere (more than two-thirds of the oxygen we breathe). This life in the ocean is fragile, somehow more fragile than life on land. Man is now producing chemical poisons that persist and go on poisoning, long after their initial use.

It may have surprised the Borgias when they developed poisons potent for their time, that very small quantities could destroy very large people. This is why we cannot take comfort in the fact that the oceans have 330 million cubic miles of water; if our poisons, such as DDT, are potent and tend to concentrate in the life chain, then the volume of water has little to do with the effects. And still we take refuge in the boundlessness of the seas.

This crisis cannot be dealt with as an isolated problem. Geographically, there is one ocean in the world.

As Dr. Heyerdahl pointed out, the United States can lead in responsibility in impressing other governments with the urgency of the situation, and in encouraging international cooperation and action. The problem cannot be isolated from the population phenomena. It cannot be isolated from politics. It cannot be isolated from economics, as Senator Pastore pointed out. There is really not a choice between the economics and the environment.

All educational efforts must face up immediately to the necessity of pushing awareness that the costs of cleaning and saving our environment are ultimately to be borne by the consumer citizen. It is hardly realistic to think business could do it at the expense of profit, or that Government could do it without taxes.

How much will we pay to stay alive?

I think we would be willing to pay more than we will have to pay. But we have got to be made aware that survival has a price, and we have got to be reasonably sure that what we pay for will allow us to survive.

It is often asked if public awareness could be widened by a Systems approach, such as the aerospace industry and NASA utilized to put man on the moon. And the Systems experts invariably point to the differences in the problems that make success unlikely in ventures involving great numbers of individual human beings. What that means is that they say, "No. The Systems approach would not work."

This may be true, but I like to think that something analogous to a Systems approach might work in the following way: (Since I am an outsider, I can think what I please about Systems).

I would call to your attention that George Westinghouse was an outsider in the railroad business and he invented the airbrake, because railroadmen knew the airbrake wouldn't work. So they didn't invent it.

We are entering a phase now, the foundation of which is a start of public awareness. It has been my privilege as a communicator over the

last few years to meet top environmentalists and to help them convey their concerns on network television. The opportunity this has afforded to observe public reaction to environment material is not what I would call scientific, but I feel I know the viewing public, and while they are still capable of surprising me on occasions, I am certain they are readier for the responsibility ultimately theirs, than we may suspect.

What I am saying is, that I believe there is enough awareness—enough faith in the validity of messages already sent by experts through the media, enough sense of coherence and consensus, if you will, among those messages—that the public is soberly accepting two aspects of some pretty bad news:

(1) that there is real danger, and

(2) that in the end it is their problem and not the military-industrial complex's or President Nixon's or Ralph Nader's or anybody else's. If I am right, that they are accepting this bad news realistically, then they deserve and will applaud some bold remedial steps from their Government. And they will welcome continued expanded coverage through other media of these heavy issues.

I cannot believe it has ever been in the American character to pull the covers over its head. We always wanted to know, to fight back, to grip the reins. There is nothing new in this. Americans have always had what it takes in the chips-down situation. And so, to torture my analogy, the Systems approach I see in this becomes possible with Government and media matching in boldness what I feel is a nascent citizen sense of responsibility—awakened and ready at this moment to welcome new, strong measures for the protection of the most crucial, threatened sector of planetary environment—the seas. Such measures can be forged by you in Government working with top environmentalists.

I realize it is a worldwide problem; it cannot be solved alone by the United States, but I realize there must be some leadership by the United States.

The difference between disaster and tragedy is that disaster has no moral component.

If we faced a danger that we could do nothing about—if the earth were coming apart at the core, or if the sun were scheduled to become a nova and incinerate us—we would have to resign ourselves as best we could to disaster.

The threat we face is tragedy, not disaster, because we presently possess the techniques for remedy. Therefore, our paralysis is not technical, but social and political.

As a citizen, I am urging my Government to scout the limits of political practicability in initiating firm and, if necessary, heroic action to counteract the crisis.

As a communicator, I urge broadcasting networks and stations in concert to allocate more generous time periods for the purpose of public instruction—and to study carefully which methods of presentation lead to maximum awareness and concern—which methods risk terrifying and could result in despair and apathy—which methods will create an appetite for more information, and which might repel; and to share and pool facilities for this material in the same way that a President's speeches to the Nation are broadcast. So that viewers will have on-going, intimate access to expert opinion, and can support their Representatives to Government in the necessary action.

If we surmount this crisis, it will show the way to stabilizing life on the planet for a long future.

It will cost us a little more to survive—it has been estimated at 5 or 6 percent more—and no doubt there will be a profound change in our concept of progress.

It need not mean the end of progress. We can progress indefinitely in the gathering of knowledge, in the increase of justice, in the pursuit of human maturity and fulfillment, in the exploration of the probably boundless realm of the human psyche, in the methods of husbanding planetary resources for maximum efficiency of use, and in the understanding of what really constitutes quality of life.

This kind of progress can unfold without the dangers that come from exuberant exploitation and waste of resources. This kind of progress we can go after zestfully without poisoning ourselves.

Thank you.

Senator HOLLINGS. Thank you, Mr. Downs, yours was a most appropriate statement.

You have spread oil on troubled waters. You have re-emphasized what Mr. Cousteau and Dr. Heyerdahl, and Dr. Commoner have said: The public is aware but the Government doesn't move responsively.

How do we get the Government's attention? How do we develop an ocean Sputnik to get this country awake? You are a communicator. Can you devise a way to scare our leadership, awake them?

Mr. Downs. One of the things that would be counter-indicated would be what Neil Jacobi calls scape-goat-ism. In a democracy, particularly, merely to blame the Government when we are the Government is counter-indicated. The Government will act responsively if the public is informed properly and willing to act responsively.

This may sound a little chauvinistic, but being in mass media, I think this is a challenge to them, to be sure the public is informed in a way that means not just a parade of data in front of them, but in such a way that they can absorb the kind of awareness that is really desperately needed now.

I think you can count on the Government to respond in a proper way then.

Senator PASTORE. I agree with you, I think this is a brilliant statement, Mr. Downs. I congratulate you for it. I think it is a practical statement, a realistic one.

Don't you think, beyond the educational aspect, with which I agree 100 percent, there ought to be some kind of an incentive on the part of Government in order to encourage activity on the part of industry and labor and others in the society to meet the challenge that has been cited by Dr. Commoner?

I think you have to go a little beyond education, wouldn't you say, some kind of a tax incentive for those who do it, to make a deduction on their taxes so it will inspire them to do more, with proper regulation, affirmative action on the part of Government.

It strikes me that we have allowed ourselves over the years to so behave ourselves that we did forget ecology. Now we have become conscious of it. Now the thing is how you overcome the evils of all of these past generations. And that is an expensive process, as you point out.

I think industry needs help, not only to compete domestically, but but also with the foreign competitors.

Mr. Downs. In answering you, could I suggest further the idea of what I called semiseriously a systems approach to this. I see it as a tripod, one leg of which is Government, one leg of which is business, industry, technology, and the other leg the public, consumer citizens.

There is a tremendous potential here that needs triggering, and it will take a lot of action and force to get the triggering mechanism going. But if any one of these legs sees the other two, really understands the other two are really ready to assume the responsibility, it will be ready.

Industry, for example, if it senses that Government is going to be firm and realistic about this, and senses that the public has absorbed the fact that the public will eventually have to bear the costs of a clean environment, and survival, industry is already showing signs of responding in a very positive way, and is having trouble getting its message across because of sins of the past. The can't use public relations money to in effect do a whitewash job. But behind those messages there are in many cases some real truths, some responsible industry actions.

So it seems to me that what is needed is something that will trigger this thing to be put together all at once. Then I think all three elements will respond properly.

It might be good, I think it is good to go to Government as Dr. Commóner has done, I think it is good to blast the public with jarring material, even though it results in criticism of the media, which is the bearer of bad news. I think industry needs to be led into and sometimes forced into responsible action.

But all of these things, if they are happening at once, and can be brought to bear with equal force, I have the feeling that it will lock into place and salvation will be forthcoming.

I admit my optimism may be more a matter of internal chemistry than an assessment of facts. But if I am wrong about that, what does it matter anyway? We have got to act in such a way as to avoid despair and apathy which would insure disaster.

Senator PASTORE. Well, we have a situation where the other day we were visited by a group of people from Michigan who had made an application for an atomic electric generating plant. A situation arose that because of the cost of conventional fuel, the Dow Chemical Co., unless it was granted some kind of relief with reference to building the plant—and that would take a period of 5 years—they would have to close down.

Now that aroused a lot of people. I mean if you are in public life, you just can't sit back and say well, the devil with it, let the people be unemployed. You are getting back to your Marie Antoinette's "Let them eat cake."

The point is, people have to work, there has to be bread on the table, too. Naturally, of course, there is going to be an adjustment that needs to be made. Sometimes it can't be made simultaneously. It takes time, it takes intelligence, it takes inspiration, it takes vision. And I think of many many places where it takes a little bit of a tax incentive in order that these businesses can go ahead and do the job that needs to be done.

But there you are, we had every public official coming in urging that something be done, and be done speedily, to build that plant, and at

the same time you have a large element, you see, which was interested in the ecology, opposing it on the grounds that there would be thermal pollution, there would be this or that.

Now it strikes me that the position we are in is that we have to bring both of these two sides together somehow, and meet on a common ground, whereby the job can be done to preserve life, and, at the same time, have a survival of the economy. It is not an easy job to do.

Mr. DOWNS. No, it isn't. That is the nature of the boldness that I am thinking of.

To back up to what you were saying, I believe history has shown that nothing has ever worked for mankind t'at didn't have some sound incentive basis. All of the social progress we have made has come about not because of the majority of the citizens suddenly becoming mature enough to have compassion for their fellowman, but because it was economically expedient to move forward in this way.

I think that may be an important way of going at it. The realization it has to be done is also an important thing, and that is the role of the media.

Senator PASTORE. That is right.

Senator HOLLINGS. There has to be a profit in anti-pollution. That is what you are saying. We have to fix it in there.

Senator STEVENS?

Senator STEVENS. I think you have contributed a great deal. I listened to my friend from Rhode Island and I hope my people let me stay here long enough to understand some of these problems the way he does. And he expresses them so well.

Mr. Downs, I would hope you would repeat your comments to your viewing public and make just one suggestion, and add just one little thing, and that is the public has to pay the price.

The interesting thing about politicians is that we send out questionnaires, and we ask our people if we should spend more money for water pollution and air pollution control. The answer is "yes", and that should we do something to try and clean up the sewage problem and make certain we all have very efficient municipal and industrial pollution control. We also ask whether we should take action to protect the oceans, and the Chairman and I have a bill to authorize \$25 billion over 5 years on some new thoughts in this regard, and the answer is certainly "yes". And then we ask them if they think we ought to be able to cut taxes and they say "absolutely".

And the result you have neglected to include is that fact that, in the end, the public has to pay the price, or we are not going to succeed.

But it is a very brilliant statement and I enjoyed it very much. Thank you.

Senator HOLLINGS. Senator Hatfield?

Senator HATFIELD. I am very tempted, Mr. Chairman, to move this discussion one step further. But I shall refrain from doing so at this time. That would have been to indicate that we have resources to do all this. The Nation is not shy of resources, as I see it, financial resources, and technological resources. We have our priority, however, on destroying life and destroying it through military spending. That is where our priority is rather than on creating life and trying to correct these environmental problems. But that is another subject and another day.

I do think we ought to make very clear the public has a right to expect expenditure of their money resources, their natural resources, and all other resources to meet certain basic human needs.

It does us precious little good to develop ABM systems, to spend \$79 billion—two-thirds of the Federal tax dollar—for military purposes, if we are going to find ourselves on the short end of having a globe on which we can survive because of pollution of the oceans and atmosphere.

I don't think we have really faced up to that yet. I think we are still of the idea that it is "either-or", we have either got to spend on military programs and give them great resources, and thereby neglect these other areas.

So as I say, I don't think it is a question necessarily of financial resources. I think we have them.

Now when this whole thing is over, we in the political life will have pressure to reduce taxes. That will be the big thing, rather than transferring some of the resources we are now spending, with too few questions, on military programs to these other needs that have been limping along, undernurtured and underfed. I think we ought to start laying the groundwork now to prepare for that day, when we are out of Vietnam, when we are reducing military budgets, that we not yield then to the politically popular pressure that will be raised to reduce all taxes in correlation to those reductions in military spending, rather than transferring those resources to trying to catch up with this lost ground we have been losing more and more of on the environmental front.

But I really didn't necessarily want to get involved in this too much at this point.

I do want to congratulate you, Mr. Downs, for a great contribution and certainly say as far as one person is concerned, I don't think it is a question of adequacy of resources, I think it is a question of where we are spending it.

Mr. Downs. This is one of the reasons it seems to me education here—and I use the word loosely—public information, is so important. Because it has always grieved me to see the space program lumped in with the military effort, because the space program has as one of the tiny bits of spin-off that has been a benefit the literal pictures of the entire globe, which show, unlike the globe pictured by artists for generations, as a ball floating in a sea of cottony clouds, that indicate an atmosphere extending out thousands of miles, we see how limited the atmosphere is, we see the absence of national boundaries, and perhaps it would point up the folly of ideological strife that people have killed each other for for centuries.

I think the education aspects of this can help melt away the problem that you mention.

As far as taxes go, there is no reason to assume that all of this must be handled by taxes, because since it costs more, for example, to manufacture a pollution-free automobile than one that pollutes, it must be expected by the public that they will have to pay more for a pollution-free automobile, and this is one example of where the Government wouldn't foot the bill in that way, but the consumer would foot the bill in a more familiar or palatable way.

Senator HOLLINGS. And we can make them want to pay more taxes if we approach it in the right fashion. There is no trouble, as Senator

Hatfield said, about the capacity, the wherewithal. But the truth of the matter is, we always jump from the economy to the ecology and back to the economy, the polarization or the domestic needs as compared to defense needs. We don't really need to do that. We sat around here 2 months ago and we passed a billion dollar measure with hardly a dissenting vote to hire the unemployed. And the testimony before the Appropriations Committee was, oh, they could pick up cans, they could help ecology, clean up the parks, fill up the courthouse, fill up the State houses. There was a billion dollars going down the drain. There is another billion coming next year. And yet, we just had hearings on the West Coast. Senator Stevens, Senator Hatfield and I all attended to try to develop this. There were thousands unemployed in the Seattle area, technicians, scientists, machinists. Wilbur Smith, an official of the AFL-CIO, testified that they could easily be adapted from aerospace into oceans technology and put to gainful employment.

So the only way I know—I could say these things over and over again—but the only way we are ever going to get this message through is with people with the brilliance and dynamism of you three here this morning getting the attention of the American public and in turn of our colleagues here in the Congress to move in the right direction.

I don't know of a better morning that we have had, including the controversy, Dr. Commoner; I liked that. I don't know what the headlines will say, but you don't mind.

Senator STEVENS. If it is like the time I had a little exchange with Nader, I will get a thousand telegrams tomorrow morning about it.

Senator HOLLINGS. We thank all three of you very very much for your presentations here this morning.

(Thereupon, at 12:45 p.m. the hearing was concluded.)

